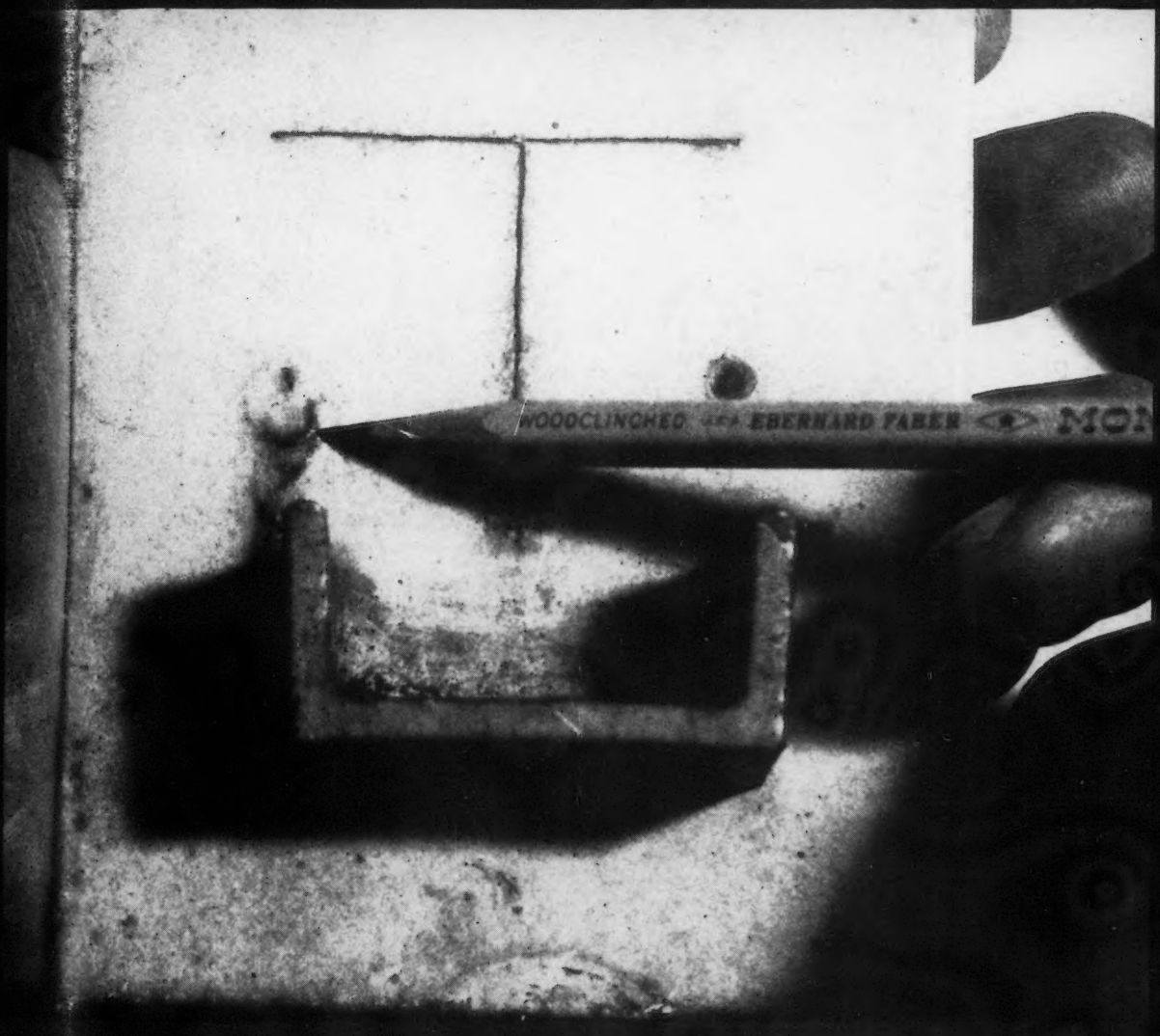
Corrosion

Official Publication
NATIONAL ASSOCIATION OF CORROSION ENGINEERS



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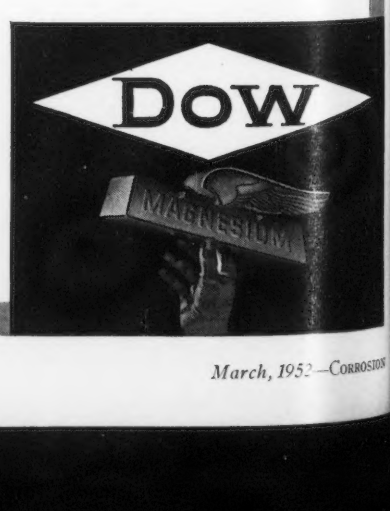

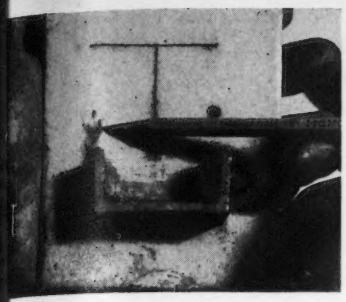

THIS MONTH'S COVER—This paint test panel developed by Kenneth Tator Associates, Coraopolis, Pa., reproducibly incorporates all surface irregularities promoting early paint failures on industrial equipment and structures. It has correlated well with service performance in two years' use. Note failure over welds and sharp edges while plane areas are in good condition, showing its advantage over conventional paint test panels, which if used with this coating, probably would have given it a perfect record.

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devoted entirely to
CORROSION
research and control

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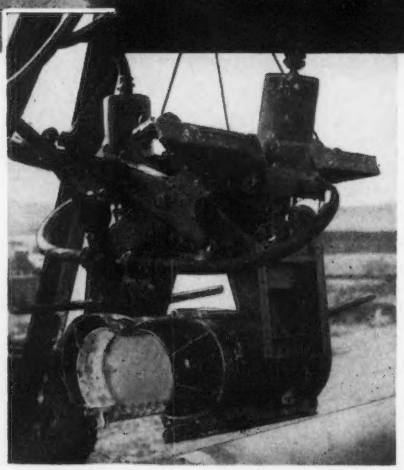

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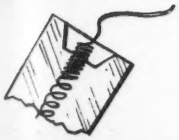

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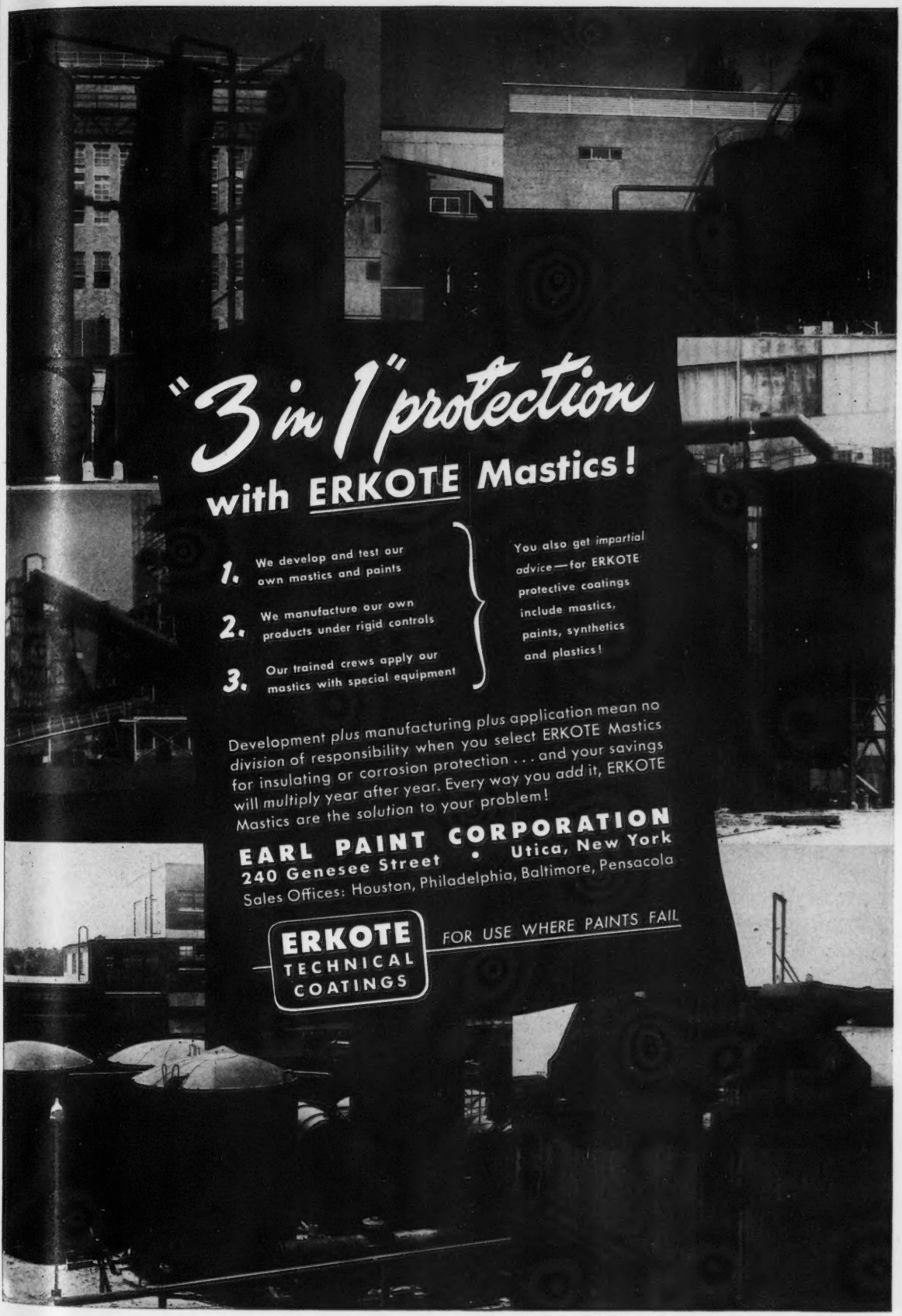
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Basically, the TYGON family consists of a series of skillfully modified and compounded vinyl resins in various physical forms: calendered or press-polished sheets; extruded tubing, channel or solid cord; molded goods; and coatings. Each form is especially suited to a particular application. Each has its use restrictions. However, all exhibit unusual general chemical resistance and desirable physical properties. All display outstanding resistance to chlorine under a wide range of conditions.

As a calendered or planished sheet, TYGON is generally used as a material of construction. In this form, it is resistant to all concentrations of chlorine at temperatures as high as 165°-175° F. When subject only to chlorine fumes, service temperatures can be raised to 200° F. Prolonged exposure to mixtures of chlorine and other chemicals, particularly solvents, is not advised without approval of U. S. Stoneware engineers.

Major use of TYGON sheets is in the lining or covering of tanks, vats, drums, hoppers, bins, blowers, impellers, fume hood and fume ducts. Considerable quantities are also die-cut into gaskets, washers and diaphragms for use as positive, durable seals, or separators, in all types of process equipment.

As extruded tubing, cord, or channel, TYGON resists chlorine in all concentrations within temperatures up to 200° F. Lengthy service with mixtures of chlorine and solvents is not recommended without qualified advice.

In extruded form, TYGON's main use is as a medium of transmission. TYGON Tubing has assumed a prominent position in both the laboratory and the plant. Its glass-like clarity, mirror-smooth surfaces, full flexibility, light weight, high strength, and long life make TYGON ideal for the smallest laboratory use or the toughest plant piping job. In the larger sizes, up to 2" ID, TYGON Tubing has proved its worth in such uses as conveying chlorine from electrolytic cells to collecting heads, as permanent or temporary lines between pressure cylinders and mixing tanks, as inlet and outlet ports on pumps and filters, as syphon hoses, as line desurgers, and as flexible connections. For use at constant pressures of 40-250 psi, and at elevated temperatures, braided jacket reinforcement is available and suggested.

As molded goods, TYGON has a wide scope of application and, in general, exhibits the same resistance to chlorine as the extruded form. Specific pressure and temperature limits will depend on the size and design of the piece, but usually are greater than those for the other forms.

Typical uses of molded TYGON include gaskets, grommets, washers, stoppers, closures, handles, bumpers and special fittings. Where desired, molded TYGON can be reinforced with glass fibers for added strength.

As a coating, TYGON takes the forms of a solvent type paint and a plastisol (TYGOFLEX). Both forms are resistant to the fumes and spillage of chlorine and its solutions in any concentration and at temperatures up to 200° F. for the paint and 250° F. for the plastisol. Naturally, care in application is important and special consideration should be given to the limits of a thin film.

When used as a paint, TYGON affords excellent protection to all types of equipment, to structural steel, to walls, and to ceilings. For mild environments, a primer and no less than two finish coats should be used. For severe exposures, a minimum of five coats over the primer is advised.

For a heavier duty coating, TYGOFLEX can be applied by spraying on hot metal and, then, fusing with heat. TYGOFLEX is also used to cast or "slush" mold flexible parts and fittings and to cover intricate shapes by dipping.

In any of its forms, TYGON provides low cost protection and a high degree of safety in the handling of chlorine and many other chemicals including acids, alkalies, oils, and greases. The different forms available and the range of mechanical, physical, and chemical properties they exhibit, permit the proper use of TYGON in many applications and under a wide variety of conditions.

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ENGINEERS, MANUFACTURERS, ERECTORS OF CORROSION-RESISTANT EQUIPMENT SINCE 1865

THE NATIONAL ASSOCIATION OF CORROSION ENGINEERS

is a non-profit, scientific and research association of individuals and companies concerned with corrosion or interested in it, whose objects are:

(a) To promote the prevention of corrosion, thereby curtailing economic waste and conserving natural resources.

(b) To provide forums and media through which experiences with corrosion and its prevention may be reported, discussed and published for the common good.

(c) To encourage special study and research to determine the fundamental causes of corrosion, and to develop new or improved techniques for its prevention.

(d) To correlate study and research on corrosion problems among technical associations to reduce duplication and increase efficiency.

(e) To promote standardization of terminology, techniques, equipment and design in corrosion control.

(f) To contribute to industrial and public safety by promoting the prevention of corrosion as a cause of accidents.

(g) To foster cooperation between individual operators of metallic plant and structures in the joint solution of common corrosion problems.

(h) To invite a wide diversity of membership, thereby insuring reciprocal benefits between industries and governmental groups as well as between individuals and corporations.

It is an incorporated association without capital stock, chartered under the laws of Texas. Its affairs are governed by a Board of Directors, elected by the general membership. Officers and elected directors are nominated by a nominating committee in accordance with the articles of organization. Election is by the membership.

Inquiries regarding membership, and all general correspondence should be directed to the Executive Secretary at the administrative headquarters of the National Association of Corrosion Engineers at 919 Milam Building, 803 Texas Avenue, Houston 2, Texas.

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An Association of Individuals and Organizations Concerned with Control of Corrosion

919 Milam Bldg. Houston 2, Texas

Vol. 8 March, 1952 No. 3

The Policy and Planning Committee of NACE

By E. P. NOPPEL, Chairman

Ebasco Services, Inc., New York, N. Y.

AMONG THE original committees established by the founders of the National Association of Corrosion Engineers is the Policy and Planning Committee.

It was early recognized that in expanding the activities of the founders' group of the Southwest to a national basis, the Board of Directors would not only need a group to study and recommend plans of organization, but would also require the continuing advice of a committee on policy and planning problems throughout the life of the association.

In 1949, it was apparent that with the increased recognition being given to activities in the field of corrosion mitigation on a national scale through participation in NACE by a growing membership from a wide range of industries, that consideration should be given to revision of the Articles of Organization and By-Laws to better meet the requirements of the Association's expanding activities. Accordingly, the Board of Directors authorized the Committee, at that time under the chairmanship of Dr. Trueblood, to proceed with revisions of the Articles of Organization, and after nearly a year of study both by the Committee and the Board of Directors, the amended Articles of Organization were voted upon favorably by the membership and became effective as of January 1, 1950.

Shortly after that, the Committee was called upon to revise the By-Laws in accordance with the changes in the Articles of Organization, and these became effective on March 11, 1951.

Under the Articles of Organization, the function of the Policy and Planning Committee is to advise the Board upon matters of policy referred to it by the Board. The Committee makes recommendations to the Board on all matters of long-term policy and many other matters having to do with policy questions and the day-to-day functioning of the organization, and is empowered to initiate recommendations to the Board on appropriate matters for the good of the Association. All recommendations of the Committee are submitted to the Board and can be made effective only upon approval and action by the Board.

The work of the Committee is of a continuing nature and the Committee consists of six members in addition to the Chairman. Appointments to the Committee are made so that one-third of the six members shall be replaced each year with each member serving a three-year term. The Chairman and the members of the Committee are appointed by the President, and the President, Vice-President and Secretary of the Association are members ex officiis.

In view of the nature of the work of this Committee, every effort has been made to have it as representative as possible of the membership of the Association, both on a geographic and industry basis. The present membership and terms of the members comprise the following:

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D. C. Glass, Pure Transportation Co., Chicago, Illinois
E. P. Noppel, Chairman, Ebasco Services Incorporated, New York, N.Y.

In view of the widespread representation, much of the Committee work must be done by correspondence.

It is the desire of the Chairman and every member of the Committee to be responsive to the needs of the Association, and the Committee will welcome ideas and suggestions from the membership on matters of policy and planning which will further the best interests of the Association.

Cathodic Protection of Moving Underwater Equipment*

By WILLIAM S. MERRITHEW*

Abstract

Successful operation of a cathodic protection system to safeguard moving underwater equipment at the F. E. Weymouth Memorial Water Softening and Filtration Plant of the Metropolitan Water District of Southern California is described. Two units with combined capacity of 200,000,000 gallons daily process and soften Colorado River water. Unit installed in 1941 was without cathodic protection, reliance being placed on an anticipated coating of sludge from lime treatment to retard corrosion. By 1944 it became obvious corrosion of members had progressed to a point where further protection was needed. Tests revealed protective coating plus a cathodic protection system assuming an ultimate 10 percent of bare metal surface was practical. A rectifier and iron pipe anodes were installed in 1944, those in the clarifier basins being designed to rotate with equipment. Test coupons and examinations of structure reveal complete protection with a reduction in potential ranging from 220 to 280 millivolts. One bay of 800 feet of drag chain scrapers installed in the second unit built in 1949 has an experimental installation of magnesium anodes designed to protect the chain, rails, drive shafts, etc., and the balance of the equipment has been coated only. Examination after a year indicates adequate protection and supports figures on estimated life of anodes on cathodically protected chain.

APPROVED CATHODIC protection installation to safeguard moving underwater equipment is incorporated in the F. E. Weymouth Memorial Water Softening and Filtration Plant of The Metropolitan Water District of Southern California at La Verne, 35 miles east of Los Angeles.

The softening and filtration plant processes Colorado River water transported from Lake Havasu through the district's 250-mile long 1500 cfs capacity aqueduct for distribution to cities in the Southern California coastal plain. The initial unit, having a capacity of 100 million gallons per day, has been in service since 1941. A second 100 million gallons per day unit was put into service in 1949. Major buildings and conduits are capable of handling two future enlargements to 400 million gallons per day.

The initial unit provided two 200-foot square, reinforced concrete clarifier basins with adjoining 50 ft. by 200 ft. flocculator basins. Unprotected Dorr clarifiers and flocculators were installed in the basins at a cost of $85,000. It was originally thought that a coating of sludge from the lime treatment process would sufficiently retard corrosion of the metal members to make expensive protective work uneconomical. This conception proved faulty and by 1944 corrosion of the members had progressed to a point where it became evident that further lack of protection would appreciably shorten the useful life of the equipment.

The equipment operates in water which varies in its chemical analysis with variations in the treatment process. Natural Colorado River water passes through the basins during periods of straight zeolite treatment while a water laden with calcium carbonate sludge is present in the basins during preiods of lime-zeolite treatment. Representative analyses of the two waters is given in Table I.

Tests conducted to determine the required current to protect adequately the 15,000 sq. ft. of metal in each clarifier and the 6,000 sq. ft. in each flocculator, disclosed that entire reliance on cathodic protection would require a current of 450 amperes. An appreciable amount of this current apparently strayed to the reinforcement in the concrete basin and returned to the metal structure by way of anchor bolts. Installation difficulties made the application of 450 amperes even more impractical. In order to provide continuous proximity of anode-to-structure it proved necessary in the case of the clarifiers to install the anodes on outriggers attached to the rake arms. This limited the size and number of anodes and placed a limitation on the total current which could be conveniently applied.

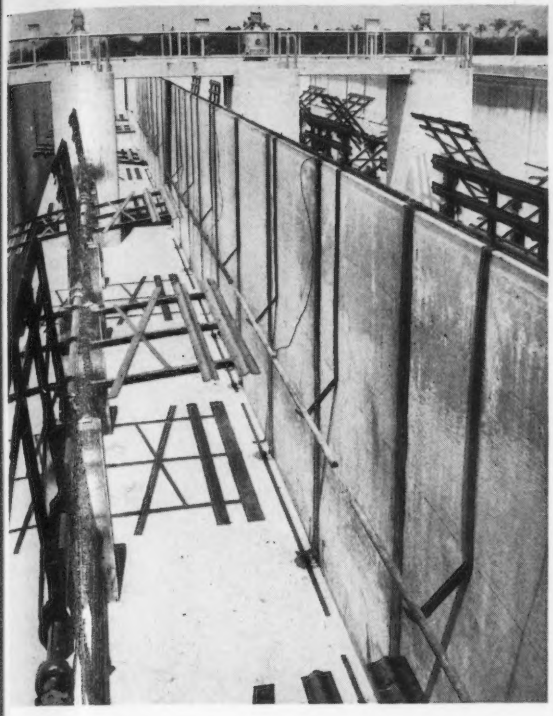
A complete reliance on a good protective coating was decided against because of the construction of the equipment. Eventual coating failure, breaks due to bending and weaving of the articulated structure and inherent holidays at the many inaccessible structural joints made any attempt at complete protection with a coating appear futile.

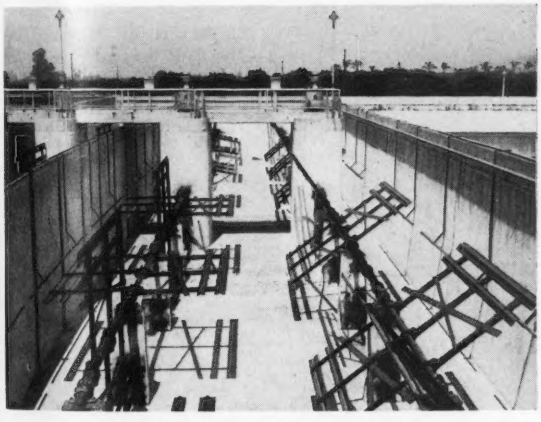
Designs based on a protective coating supplemented with cathodic protection, assuming an ultimate ten percent of the metal surface being exposed resulted in practical requirements as to power, anodes, and installation.

The installation was made in mid-1944 on the latter basis. All submerged metalwork was sandblasted and coal-tar enamel coated by district forces. A single rectifier with a capacity of 60 amperes at 10 volts was provided to distribute required current to the four basins through variable resistances. Iron pipe anodes were installed in the flocculators on wall brackets in 20-foot lengths (Figures 1 and 2). A series of anodes parallels each of three paddle shafts for its 200-foot length. Anodes of the same type are used in the clarifier basins (Figure 3) but rotate with the equipment, a series of anodes being placed 10 feet to each side of the rake arms and extending their full length.

Attachment to the metal structure is by means of

★ Submitted for publication September 26, 1951.
* The Metropolitan Water District of Southern California, Los Angeles, Calif.

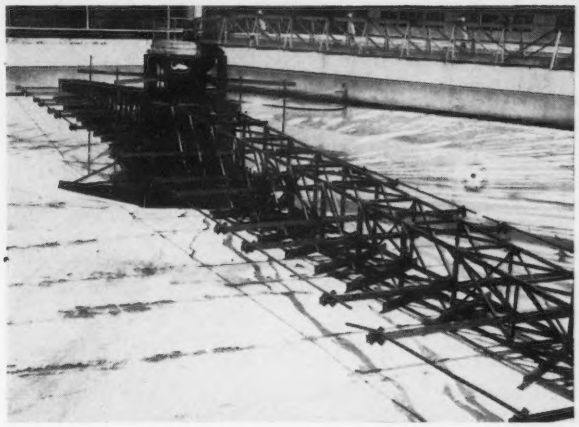


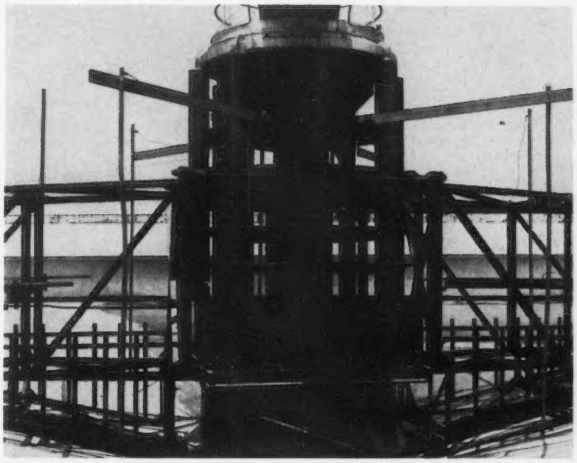


Figures 1 and 2—Two views of cathodic protection installation in flocculator basin. Iron pipe anodes are hung on coal tar enameled wall brackets. Rubber saddles insulate the anodes from the brackets. Water level during operation is six inches below the top of the dividing wall to which the anodes are attached.

redwood frames. Additional anodes (Figure 4) in proportion to the area of metal to be protected are hung vertically adjacent to, and rotate with, the center column. To insure against possible damage to the bearings, if they were used for electrical contact, two ¼-inch x 1-inch copper collector rings 11 feet in diameter were attached to the rotating center column of the clarifier. The negative ring contacts the structure directly and the positive ring is insulated from it. Spring loaded bronze finger contacts are used, to which the positive and negative wiring is attached. The flocculators required but a single sliding negative return because the anodes are stationary.

The installation operating in water with a resistivity of 970 ohm-cm. reduces the structure to water potential by an average 250 millivolts, distributing six ampers to each flocculator and nine amperes to each clarifier—a total of 30 amperes at 5.5 volts. The reserve capacity of the rectifier and the variable





Figures 3 and 4—Two views of cathodic protection installation in Dorr clarifier basin showing method of attaching anodes which rotate with equipment. Pictures were taken during installation and wiring is incomplete.

TABLE I

Analysis of Water from Settling Basins

CONSTITUENTS	Symbol	Natural Colorado River Water, Parts per Million	Lime Treated Water Parts per Million
Silica	SiO_2	8.0	11.5
Iron	Fe	Tr.	Tr.
Calcium	Ca	79	58
Magnesium	Mg	28.5	28
Sodium	Na	99	99
Potassium	K	4	4
Carbonate	CO_3	4	7
Bicarbonate	HCO_3	137	68
Sulfate	SO_4	290	290
Chloride	Cl	79	79
Nitrate	NO_3	0.2	0.2
Boron	B	0.1	0.1
Fluoride	F	0.4	0.4
Total Dissolved Solids	.....	661	611
Hardness as $CaCO_3$:			
Total	.....	315	260
Carbonate	.....	118	68
Noncarbonate	.....	197	192
Free carbon dioxide	.....	0	0
Hydrogen ion concentration	.....	8.4	9.0
Electrical conductivity x 10^6	.....	1040	972

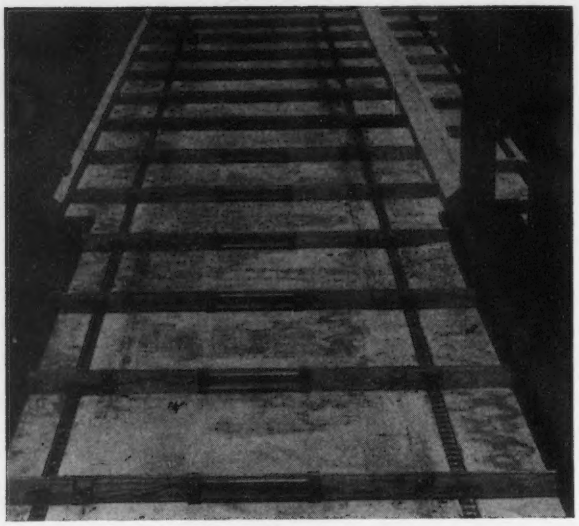


Figure 5—Magnesium anode installation in clarifier basin employing drag-chain scrapers. Concrete deck seen in picture divides basin at half depth. Floor below is scraped by opposite edge of redwood flight in its return path.

resistances in the four circuits will permit increasing the current and variation of its distribution if future coating deterioration makes it necessary.

The reduction in potential between structure and water has been measured with power on as against power off with a copper sulfate electrode placed six inches from the structure. The reduction in potential has been very uniform, varying from 220 to 280 millivolts. Test coupons attached at various points throughout the structure and inspection of metal surfaces which have become bared show complete protection and the presence of a hard calcium carbonate deposit. The partial replacements of dissipated anodes made twice during eight years of operation together represent a 50 percent replacement of original anodes. Other maintenance costs have been limited to power consumption and one rectifier stack replacement.

The second unit constructed in 1949 duplicated the two original flocculator basins. The additional clarifier basins, although the same size as the original were structurally revised to provide a horizontal dividing slab at half depth and Link-Belt drag chain scrapers were used for sludge removal. The flocculator equipment, a practical duplication of the original was coal-tar enameled at the time of installation and was cathodically protected in approximately the same manner as the unit which had proven so satisfactory.

Investigation of means of protecting the 21,000 lineal feet of drag chain in the two new clarifier basins, together with an equal amount of metal in the form of rails, chain return channels, drive shafts, sprockets, etc., disclosed a power requirement of 270 amperes at 7 volts and 50 tons of iron pipe anodes for proper distribution of current. The flexible chain and sliding contact between other metal parts would not permit reduction of requirements by means of a rigid coating, while so many anodes which could fail and foul the flights could not be tolerated. The successful protection used on the Dorr clarifiers could not be readily applied to the chain type scraper.

Investigation revealed protection with magnesium anodes attached to the flights appeared to be feasible. Studies showed they could provide a current density of 3 milliamperes per square foot of chain surface with reasonable sized anodes in water having a resistivity of 970 ohm-cm. It was estimated that to provide such a current density to the metal in the two basins would require 6 tons of magnesium with a life expectancy of 14 years at an initial cost of $12,000 and an annual operation and replacement cost of $1200.

In view of the estimated costs and lack of insurance that the available current density would provide adequate protection, the complete installation was deferred. One bay or 800 feet of chain was protected in this manner as a test installation while the balance of the equipment was temporarily coated with a rust preventive grease coating. Each redwood flight on 10-foot centers (see Figure 5) was fitted with four 1.3-inch diameter by 2-foot 9-inch long magnesium anodes, two to each face, centered between the chains which are 10 feet apart. The anodes were connected to the flight attachment links.

The test installation has been in operation one year. Inspection indicates adequate protection and supports figures on the estimated life of the anodes.

Figure 1—Gulf Oil Corporation refinery, Port Arthur, Texas.

Refinery Painting*

By W. B. COOK

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Abstract

The varied conditions to which petroleum refinery equipment surfaces composed of different materials of construction are exposed are enumerated. Selection of surface preparation methods and paint coating systems to provide the best economic results for protection, decorative effect and other benefits to be derived from the application of paints and coatings to surfaces exposed to specific refinery conditions, are discussed.

DUE TO A HIGH DEMAND for petroleum products at relatively low cost and to strong competition in the refined product marketing field, the petroleum refiner must process crude oil in large quantities.

This requires a vast refinery lay-out of storage and transfer facilities for both crude and refined products, large and varied types of complicated processing units, power generating plants, maintenance shops, pump houses, warehouses, laboratories, administrative office buildings, fire fighting facilities and equipment for furnishing huge quantities of water for steam generation, condensing, cooling and other purposes.

Surfaces of this physical equipment, composed of various materials of construction, are subject to a wide variety of conditions which dictate a policy of coating the majority of them with paint or other coatings.

Merkle[1] has referred to a petroleum refinery as a vast chemical plant involving all the problems of protection against exposure to high concentrations of moisture, acids, alkalis, petroleum solvents and oils.

In painting work at a large refinery such as that of the Gulf Oil Corporation plant at Port Arthur, Texas, many problems are encountered, some of which are common to other phases of the oil industry, while others more closely resemble those of the chemical plant. Figure 1 shows a general view of a large portion of this refinery and illustrates the vast expanse of exterior surface area coated with paints.

Because of the solvent properties of the petroleum hydrocarbons processed, their inflammable and explosive characteristics, the chemical attack potenti-

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alities of sulfur compounds present in some crudes and some of the partially processed products, the chemical attack and solvent power of refining agents used in processing, extremes of temperature and pressures employed in the refinery operations, and a variety of construction material surfaces involved, several methods of surface preparations must be employed, and a number of different types of coating systems used.

In his article on "Recent Developments in Paints for the Petroleum Industry," Oxley[2] lists a number of reasons, in addition to protection and decorative purposes, as the basis for selection of suitable paints. Chief among these applying to refinery equipment are:

1. Heat reflection to prevent loss of volatile products by evaporation.
2. Prevention of product contamination.
3. Sanitation and good housekeeping.
4. To facilitate the cleaning of equipment.
5. Light reflection for providing good visibility and improving lighting effect.
6. Resistance to abrasion, mildew, heat or flame.
7. Identification.

In addition to these, paints are used in the petroleum refinery for safety markings, directional and employee informative signs, for minimizing the effect of erosion and increasing liquid flow, prevention of iron bacteria growth and for company advertising purposes by way of distinctive markings of company properties.

With the economic viewpoint constantly in mind, and continually guarding against false economy measures, the refinery painting program at Port Arthur is designed to provide the afore-listed properties, as well as maximum protection and good appearance, at minimum cost.[3] To accomplish this, paint systems are selected for field test application on the basis of specific types which are designed by the manufacturer for application to surfaces of certain construction materials and are known theoretically and by laboratory testing to be resistant to specific conditions.

Robertson[4] has classified the various types of coatings according to "family" and has listed the outstanding qualities of each in his article entitled "Classification and Uses of Plastic Coatings." This might very well be used as a guide in the selection of paint coating systems for field application trial to meet specific refinery conditions.

Types of construction material surfaces in this refinery for which suitable paint systems must be recommended include steel, galvanized iron, aluminum, concrete, brick, plaster, transite, wood and insulating media such as magnesia block, foamglass, and the recently developed calcium silicate block which is rapidly gaining favor as a refinery insulating material.

In the field of painting, as in other lines of endeavor, certain basic principles have been established through years of experience and experimentation in the formulation and application of various types of protective and decorative coatings. It has been established that the different types of surfaces and exposure of these surfaces to varying conditions, require: first, properly prepared surfaces; second, specifically balanced formulations of coating ingredients, and; finally, application and drying conditions that will allow the coating system to cure properly before being exposed to attack by the deteriorating forces it was designed to resist.

The importance of good surface preparation cannot be over-emphasized. Provision of a clean, dry, surface, free of corrosive contaminants is just as important as selection of the proper coating system. For no matter how good a paint film is it must adhere completely to the surface for a definite length of time in order to do the job for which it was designed. Paints are formulated for application to specific types of surfaces and surface preparations. Therefore, the paint manufacturer recommends types of surface preparation for each system and, to obtain best results, it is advisable to follow these recommendations as closely as possible.

Taking the aforementioned construction materials in reverse order, the insulating materials need little surface preparation other than that they be dry and free of chemical contaminants. Coatings of the bituminous type such as gilsonite-asphalt mixtures or coal tars are applied to these for sealing out moisture. In most applications of insulating materials over steel, it is advisable to thoroughly clean the steel and apply an inhibitive type of primer prior to insulating, because cases of severe corrosion caused by moisture accumulation underneath the insulation have been encountered. Because gloss retention of asphalt and coal tar coatings is not great and because they have a tendency to alligator badly when exposed to sunlight a finish coat of medium oil alkyd black may be applied to provide a gloss black finish and prevent alligatoring. Should a finish color other than black be desired, a seal coat of aluminum paint containing asphalt, or a phenolic aluminum which may also contain some vinyl resin, should be applied to prevent bleeding of the mastic prior to application of a compatible weather coat finish.

Wood, used for rough services such as walkways, inside of earthen firewalls, leading to tanks in the storage field, etc., is usually treated only with a wood preservative. Wooden buildings, of which there are few, wooden window frames, etc., are painted according to best domestic practices; that is, a penetrating type of thinned primer is applied to clean, dry, bare surfaces and finish weather coats of the desired color, usually white or ivory, but in some cases standard varnish type aluminum, are applied, making sure that no moisture is entrapped between coats. Since hydrogen sulfide is sometimes present in the refinery atmosphere, and because this compound reacts with lead pigments to form the discoloration products of lead sulfide and lead sulfate, only lead-free paints of the fume and mildew resistant types are used except as primers for steel under some conditions. Mildew, accumulated dirt, discoloration products and contaminants are removed from wooden surfaces prior to painting by scrubbing the surfaces with tri-sodium phosphate solution, flush-

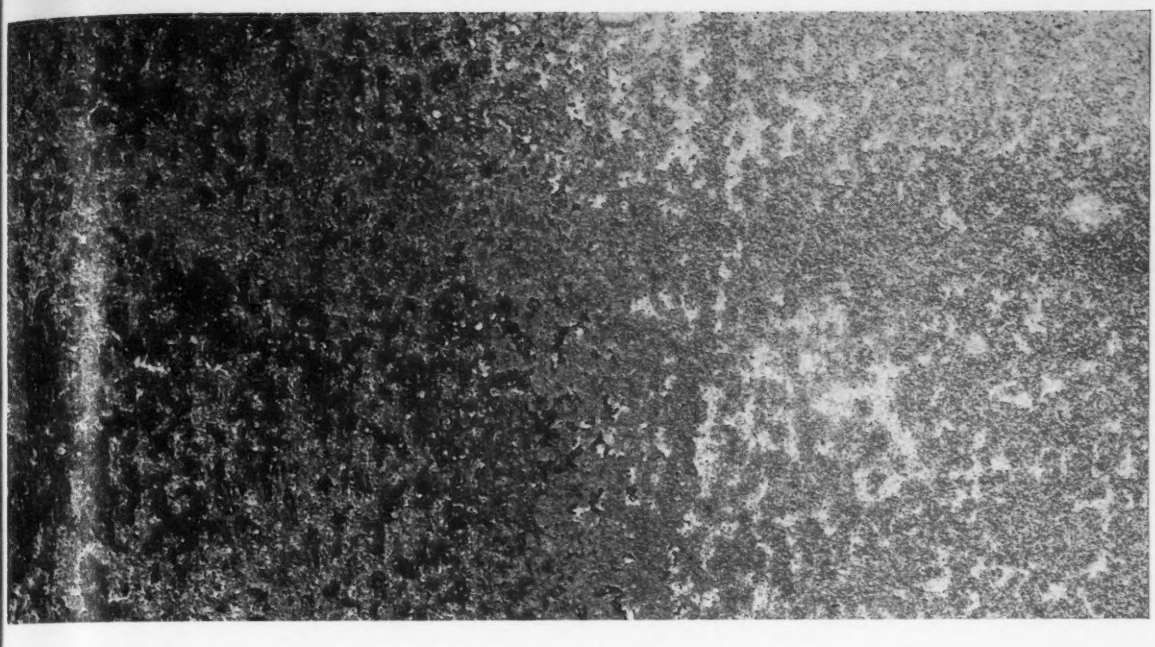

Figure 2—Close-up of a freshly blasted portion of new tank surface compaared with adjacent unblasted portion weathered for six weeks in hot summer.

ing with water and allowing adequate drying prior to painting.

Transite is painted only where a decorative effect or light or heat reflection is desired. The use of corrugated transite for building walls and roofs in refineries has gained in favor over the past several years, because its resistance to chemical attack is good. It is not normally painted as its light gray color conforms very well with other exterior paint color schemes. However, where this material is painted for the aforementioned reasons, certain brands of asphalt aluminum paint have been found to offer very good hiding in one coat, whereas when using other types, such as fume resisting medium oil alkyd white, standard varnish type aluminum or alkyd types in other colors, better hiding and adhesion is obtained by first applying a penetrating, thin, base coat such as a flat wall paint, unpigmented aluminum vehicle or the finish coat paint thinned appropriately.

To avoid paint failures on plaster surfaces, careful inspection should be made prior to painting to make sure the plaster is thoroughly free of moisture and that no free alkali is present. Although it is now generally recommended that glue and varnish sizes not be used for sealing purposes, but rather that oil base paint systems designed especially for this type of surface be selected, mildew or chemical reaction discoloration has been encountered which has been successfully sealed on repainting by usage of a varnish-turpentine-alkyd enamel mixture, followed by a coat of fume resistant flat oil paint and a finish coat of a compatible fume and mildew resistant weather coat.

Brick and concrete are porous and must be thoroughly free of moisture prior to painting to avoid blistering when heat draws or drives this moisture to the surface. Whatever paints are used for these surfaces, should have properties conducive to penetrating these pores without bridging over upon drying. Of course, the finish coats should have good resistance to whatever conditions to which they are exposed. Etching of dense concrete, and/or neutralization of free alkali in that freshly finished, with a 10 percent muriatic acid solution, followed by thorough flushing with fresh water and complete drying prior to painting, aids adhesion materially. One difficulty with painted concrete floors in a refinery is damage resulting from the use of kerosene or kerosene-soapy water solutions for cleaning. Under certain conditions, this is considered safe practice and the use of this low cost, readily available refinery product affords a glossy sheen to painted floors, but its absorption into the paint film is very detrimental to its adhesion. Thus the use of kerosene for cleaning painted surfaces defeats attempts to improve adhesion by special means.

Use of sheet aluminum has definitely proved this material must be protected with paint in the Gulf Coast refinery atmosphere. Alkali disintegration from oyster shell dust, and salt atmosphere and weak acid, attack showed effect within less than two years' time after erection. Etching of this metal with a phosphoric acid solution to provide a good paint bond, priming with a medium oil alkyd vehicle-zinc chromate-iron oxide type of primer and application of a finish coat resistant to the atmospheric conditions have provided very good protection against this damage.

Heavily galvanized iron has given as much as six to eight years' service in the plant without painting before beginning to rust, at which time it has been painted to give many more years of service. Lighter galvanized sheeting has required painting much sooner than this. Galvanized iron in the plant is

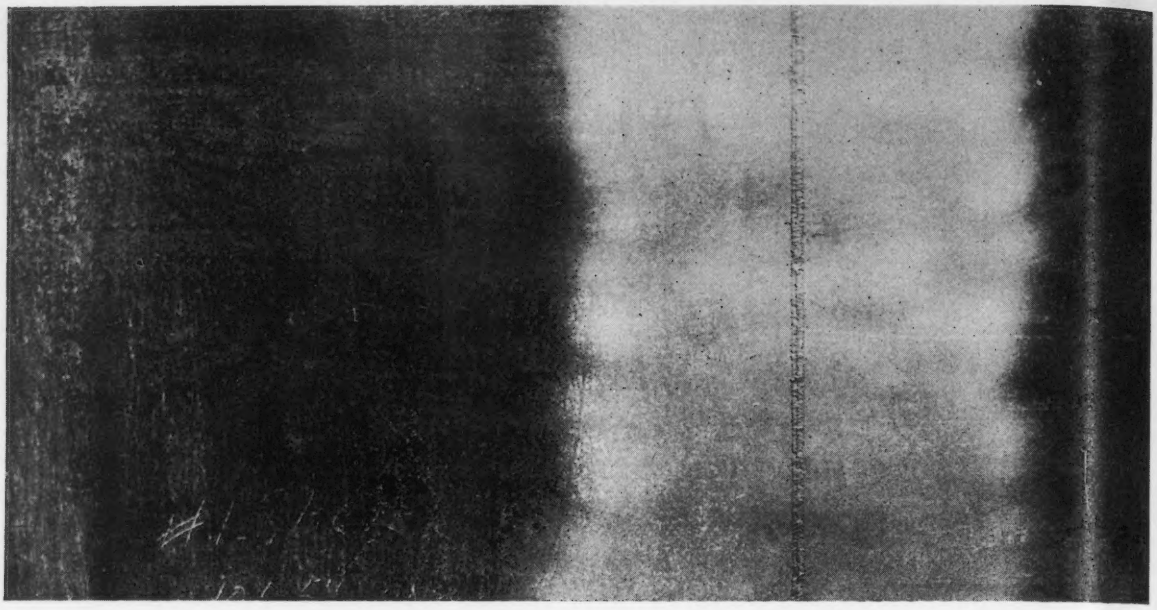

Figure 3—Same area as Figure 2 from a distance of about 10 feet.

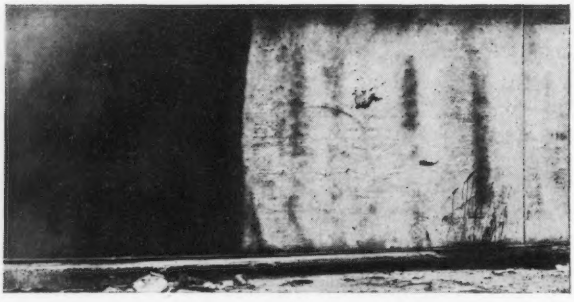

Figure 4—Phosphatized surface over part of which primer has been freshly sprayed.

seldom painted when new, but in the few cases where this is done, the palm oil is either removed by solvent washing or by a short weathering period. Zinc dust primers, formulated especially for galvanized iron, are first applied for affording good adhesion of the paint film. Inhibitive primers containing zinc chromate, lead chromate or red lead are used for rusted galvanized surfaces.

The most widely used refinery construction material is steel and because steel surfaces corrode rapidly and present an unsightly appearance when exposed unprotected to atmospheric and chemical attack, they constitute a large majority of the surfaces coated with paints.

New steel is sand blasted wherever this method of surface preparation is not hazardous due to presence of light hydrocarbon vapors or is not damaging to moving machinery parts. Other methods of steel surface preparation include use of mechanical and hand powered wire brushes, chipping and knocking hammers, scrapers, etc.; steam, chemical solutions, high flash-high solvency solvents as cleaning aids and metal preparatory solutions such as phosphoric acid and chromate washes.

However, as a consequence of fire and explosion hazards around equipment in which low flash hydrocarbons are handled, non-sparking scraping tools must be used, which, being composed of the softer metals are difficult to keep sharp and naturally do not perform as well as steel tools. Extreme care must be exercised with cleaning agents and metal preparatory solutions because of personnel hazards involved. Continuous operation of refinery equipment, except for widely separated short cleaning and repair periods often prevents employment of the most desirable method of surface preparation prior to painting.

For the sand blast preparation of steel surfaces, Liebman[5] has set definite limits for specific classifications of blast finishes, as follows:

	Sq. Ft. Produced per Machine Hour	Approx. Sand Consumption per Minute	Nozzle Size	Air Pressure
1. White Surface	75- 140	30 Lbs.	5/16″	90-95 Lbs.
2. Commercial	275- 400	30 Lbs.	5/16″	90-95 Lbs.
3. Sand Brush-Off	650-1000	30 Lbs.	5/16″	90-95 Lbs.

These limits might very well be used as standards for sand blasting of refinery equipment steel surfaces. A normal blasting rate on the exterior of new storage tanks has been well established at between 400 and 600 square feet per machine hour, which would be classified near the lower limits of the commercial grade and somewhat better than the sand brush-off. Figure 2 shows a close-up detail of a freshly blasted portion of a 144 ft. diameter x 48 ft. high new tank surface compared with an adjacent unblasted portion which had weathered for about six weeks during hot, summer weather.

These same areas are shown in Figure 3 from a distance of about ten feet. The operating department

was crowding the maintenance department to complete the sand blasting of this tank before its being pumped into, because storage space was needed for gas oil production from the stills, so the usual practice of priming the sand plasted portions the same day as blasting is done was not carried out, and blasted portions were allowed to weather from overnight to three days. A thin film of rust formed during this period which was passivated and converted to a harmless phosphate film by spraying the entire surface with a phosphoric metal conditioner solution prior to priming. Figure 4 shows the phosphatized surface together with a treated portion over which fresh primer has just been sprayed. Incidentally, this phosphatized surface was wetted thoroughly by a sudden downpour of rain the day before this photograph was taken but no rust developed as a result. For application of the organic coatings such as vinyls and baking phenolics the "white surface" class of sand blasting is required but this additional expense is not considered to be justified for ordinary exterior painting work.

On steel equipment in areas subject to hydrogen sulfide fumes, two coats of a medium oil alkyd zinc chromate-iron oxide primer and one finish coat of medium oil alkyd black or gray, or spar varnish type aluminum are used. In relatively chemically clean atmospheres, a prime coat of oil type lead chromate and an intermediate coat of oil type red lead-iron oxide and one finish coat of medium oil alkyd black or gray or spar varnish type aluminum are used. In repaint work, or on new steel where mill scale cannot be entirely removed, only the latter two coats are applied. Sometimes they are preceded by spot priming of badly pitted spots with the aforementioned first coat material.

Storage and process unit rundown tanks for high flash point and dark colored oils and all crude tanks have black shells because possible weeping of the dark colored oils on the old-type riveted tanks does not make as bad an appearance on black shells as on those finished in a light color. A standard width upper band of the shell and the roof of these tanks are finished either in aluminum or aluminum colored gray for reflecting heat from the vapor space. Tanks in lighter-than-kerosene service are painted all-aluminum or aluminum colored gray with exception of a black band near the ground level to hide dirt accumulations from rain splashes. The bottom six inches of the exterior of tank shells is coated with a rust preventive amorphous wax type refinery product after the final coat of paint has dried to provide additional protection against moisture at this level.

The surfaces of processing units are painted according to the scheme previously described for the materials of construction employed. Very little sand blasting can be done due to operational hazards. Finish color schemes for process units are black, aluminum or light gray or a combination of these depending on the nature of the operation. Stairways, walkways, handrails, etc., and the lower exterior portion up to five feet above ground floor level, are painted black for better hiding of dirt and oil deposits.

Chemicals used in the refining processes include sulfuric acid, aluminum chloride, caustic soda, sodium plumbite or litharge solution and copper salts. In manufacturing of aluminum chloride, chlorine is derived from salt brine. Sulfuric acid is recovered from sludge and fortified back to strength in the acid plant operations. These operations, the use of refrigerants, such as ammonia, for refining processes requiring low temperatures, of large quantities of salt water for cooling and condensing purposes and water treating activities, necessitate the coating of some surfaces with special chemical resistant systems.

Medium oil alkyd and alkyd modified chlorinated rubber systems have been found practical, economic coatings for protection against relatively mild acid attack by combined acidic fumes and atmospheric moisture or moisture condensed on surfaces as a consequence of temperature and pressure differentials. Air drying phenolics have shown good resistance to this condition, but the fading characteristic of this type of finish coat when exposed to weather disqualifies it from an appearance standpoint. This deficiency has also been found on chlorinated rubber finishes to a somewhat lesser extent. For the more severe acid attack at the acid and aluminum chloride plants, frequent recoating with low cost coal tar and asphalt paints, where a glossy finish is not important and oil spillage or leakage is not a potential paint dissolving factor, has been found to be economically advantageous.

Chlorinated rubber and alkyd modified chlorinated rubber coating systems have been found to give very good resistance to caustic soda solution spillage. On well weathered rusted tanks, completely free of mill scale and old paint, which are subject to caustic spillage and located in light oil areas where it is too hazardous to sand blast, application of an alkyd red lead primer, followed by careful application of a "flat" chlorinated rubber barrier coat and two vinyl finish coats, very carefully applied to avoid lifting of undercoats, as mentioned by Harvey,[6] has proved successful from both the application and the durability angles. However, on a new steel tank, partially covered with mill scale, peeling of portions of the entire film was experienced within six months after application of this same system, which was preceded by a weak phosphoric acid solution wash, the purpose of which was to improve adhesion of the primer and passivate corrosion products on the surface. Apparently some of the phosphoric acid was left unreacted on the surface, especially on the mill scale on which this type of metal preparatory solution has little reaction effect.

Because aluminum pigment in a paint film is rather quickly disintegrated on exposure to acid or alkali conditions, gray paints formulated with titanium pigment and colored with lamp black to an aluminum-gray shade have proved to be much more resistant. For resistance to mild acid attack, these grays are formulated with alkyd types of vehicle, while chlorinated rubber types are incorporated into those for exposure to alkali.

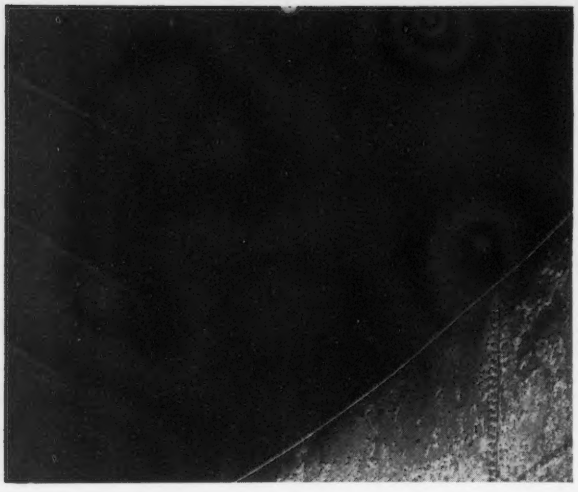

Figure 5—Underside of a roof of an 80,000-barrel tank taken shortly after application of a 5-coat vinyl system.

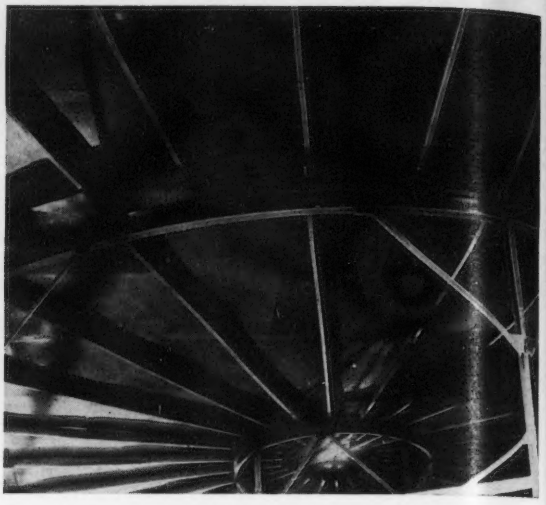

Figure 6—Vapor space of same tank as in Figure 5. Both were taken before tank was put back in service.

For most exterior chemical exposure, the cost-durability ratio has been experimentally proved to be too high to justify very extensive usage of the vinyls although these are economically advantageous for use on limited surface areas where short-term replacement of equipment is necessary due to chemical corrosion.

Some failures, based on economics involved and caused mainly by corrosion developing underneath the coating film and resulting in almost complete loss of adhesion after about two years, have been experienced in experimental applications of vinyl type coatings to interiors of sour distillate rundown tanks, while an economic advantage has been proved by others. The durability of these applications has ranged from two to four years.

The economics of experimental applications of vinyl type coatings to vapor-space interiors of sour crude storage-working tanks has not yet been definitely proved, because metal failures have not occurred in three or four years since applications were made. This is insufficient time to show cost justifications without making detailed interior inspections. It has been impossible to make such detailed inspections, because of continuous service of these 80,000 barrel tanks.

Figures 5 and 6 are photographs of the underside of a roof and vapor space of one of these tanks taken shortly after application of a 5-coat vinyl system and before the tank was put back in service. The vinyls have a very definite heat limitation and will not withstand the steaming commonly used in refineries for gas freeing vessels without blistering.

One baked phenolic coating application has been made on the entire interior of a 10-foot dia. by 70-foot long, horizontal, cylindrical propane storage drum. On inspection after only eight months of service, this coating had blistered considerably along the bottom. This was attributed to inability of the applicator to obtain a sufficiently high baking temperature with heated air circulation, although the tank was completely insulated on the exterior with glass wool blanketing. Baking temperatures of about 275 degrees F were claimed by the applicator to have been reached, but an air outlet temperature of only 190 degrees F at the bottom of the tank was observed. In shop oven-baked phenolic coating work it is understood baking temperatures in the order of 300 degrees to 450 degrees F are obtained.

Selection of paints for hot surfaces exposed to weather presents a special problem. For temperatures above 200 degrees F, primers are not recommended. Low solid content heat resistant aluminum, special heat resistant black and high zinc dust content gray paints are used for temperatures above about 350 degrees F. Most critical surface temperatures are from 200 degrees F to 350 degrees F and one-coat applications of medium oil alkyd or oil type paint containing some graphite seem to be about as good a choice as any for this temperature range. Operating conditions in most cases prevent proper practice in sand blasting these surfaces and, following application, properly bringing them gradually up to maximum operating temperature immediately after drying. Because corrosion prevention is not the primary purpose of painting these hot surfaces, but rather appearance, high cost is hardly justified.

It has been found that frequent recoating of most above-ground oil transfer pipe lines in open conduits with low cost coal tar paint is more economical than application of better quality systems requiring expensive surface preparation. Wrapping pipe with polyethylene or vinyl adhesive tape has proved to be more economically advantageous than paint coatings in some locations where the pipe is subject to severe chemical attack or high moisture conditions. Hot applied coal tar enamels are used on some of the water handling equipment.

Corrosion engineers' primary interest in paints and painting practices is only in their use in protecting equipment surfaces from deteriorating attack by destructive forces. To protect these surfaces to economic advantage should be the main object in this phase of corrosion mitigation. However, in con-

nection with refinery painting, certain other economic aspects must be considered. Surface preparation methods and application of paint systems known to give best protection, but requiring idle equipment, must sometimes give way to less desirable systems that allow plant production, the income from which overshadows increased cost resulting from more frequent painting. Appearance of a well painted plant also has a certain advertising value and this, along with other factors such as the effect on employee morale and efficiency, etc., cannot be measured in dollars and cents.

Purely from the protective angle and to a certain extent from that of appearance, the economics of painting versus non-painting, or that of one painting system compared with another, may be fairly conclusively proved through a study of durability results developed from a comprehensive program of intelligently planned, practical field test applications in which actual costs and corrosion rates are given due consideration.

It should be kept in mind, that cost-per-gallon of paint is a poor criterion for gauging the economic value that may be derived from this variable commodity. A low cost-per-gallon system may run considerably higher in cost-per-unit-area of applied dry film than one of much higher cost-per-gallon. Therefore, cost-per-unit-area of applied dry film per time-unit of durability, both from the protection and appearance viewpoint, based on plant scale applications, made under normal plant operating conditions, constitute the recommended method by which painting systems can be evaluated concretely.

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A Review

Chemical Treatment to Mitigate Corrosion*

By J. G. JEWELL

Introduction. Most of the published work on corrosion control by chemical methods has dealt with inhibitors of two general types: agents characterized by pronounced surface activity and ionic agents that enter into certain types of reactions on the local anodes and cathodes of a corroding metal surface. This review of the subject also will be devoted largely to inhibitors of these two types. However, a great many chemical and physical chemical principles have been applied in one way or another to stop or control the corrosion of metals and certain others of these also will be mentioned.

The chemistry of corrosion is in most instances so complex and practical corrosion problems usually differ from each other in so many important respects, that no few chemical corrosion control methods even approach universal applicability. Every corrosion problem is in some respects unique. Not only is the chemistry of corrosion itself important, but concomitant chemical and physical chemical considerations—product contamination, catalyst poisoning, heat transfer, and others—are often of equally great importance in a specific corrosive situation.

To give an example, one method of stopping acid corrosion is, of course, to remove the acid by neutralization. Ammonia is sometimes used for this purpose and is particularly valuable in some applications because of its volatility. It is a standard practice to add ammonia to the vapor space in crude petroleum lease tanks to control corrosion by hydrogen sulfide gas and water that condenses on the tank walls above the liquid level. However, the general usefulness of ammonia is limited by one of its reactions. It cannot be used in copper or brass equipment because it attacks copper and at a much more rapid rate than do most acids. The reaction involves the formation of the well-known copper-ammonium complex.

An example of the same nature in which the chemistry is much less clear-cut is the use of sodium dichromate to inhibit aluminum in sodium chloride solutions. The treatment is very effective at room temperature, but in boiling salt water the corrosive attack on aluminum is actually increased by the dichromate ion.[8]*

Neutralization and Buffering. Acid neutralization has been mentioned as a method of corrosion control.

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* References in this review are listed alphabetically by authors' names, consequently reference numbers are not in sequence.

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Abstract

A review of surface active and ionic type corrosion inhibitors, methods of neutralization and buffering, removal of corrosive agents, self-repairing coatings and bactericides are discussed. Anodic and cathodic agents are considered at length and the various factors incident to the use of these types of inhibitors described.

Industrial applications of anodic and cathodic agents are given in detail, percentages of some agents customarily used for specific services are listed. Organic inhibitors, adsorption inhibitors, pickling inhibitors, oil-wetting agents and special applications of anti-corrosion additives are considered.

Neutralization is effective because it decreases the hydrogen ion concentration in a corrosive solution, a result that can sometimes be achieved more economically by buffering. Sodium acetate buffers acetic acid and since it is a reaction product in the neutralization of the acid with sodium hydroxide or with a basic sodium salt, its formation may decrease the amount of alkali required to produce a given degree of corrosion protection. Again, a mixture of calcium sulfate and calcium carbonate in the solid phase is known to buffer carbonic acid effectively.[6]

Removal of Corrosive Agents. Corrosive agents may sometimes be removed from a system. Small amounts of hydrogen sulfide can be easily removed from solution by adding ferrous sulfate or other heavy metal salt. Sodium sulfite is often used to remove dissolved oxygen from brine, it reacting with the oxygen to form sodium sulfate. Sodium sulfite has been widely used in boiler water treatment.

Self Repairing Coatings. In some instances it is possible chemically to form protective coatings directly on the surface of a corroding metal, which repair themselves when ruptured provided the proper chemical environment is maintained. Formaldehyde is used to treat oil wells that produce hydrogen sulfide.

The formaldehyde reacts with the produced sulfide gas at the tubing surface and the reaction product polymerizes to form an excellent protective coating. As long as formaldehyde is maintained in the well brine, the coating is kept in good repair. A similar coating can be built up in oil-well tubing by adding water-soluble melamine resins to the brine, which also polymerize to form a self-repairing protective coating on the tubing surface.[30]

Bactericides. Even bactericides have found application as corrosion inhibitors. Certain bacteria, in whose metabolism the oxidation of ferrous iron to ferric iron plays a basic part, are known to be responsible for the pitting and tuberculation of steel in some instances.[31] Obviously in such cases a good bactericide may be a good corrosion inhibitor. Sulfate reducing bacteria also promote corrosion in some environments and again bactericides may be applicable as corrosion inhibitors.

Anodic and Cathodic Agents. Almost any reagent will attack any metal, except the noble metals and except those metals that form relatively insoluble compounds as initial corrosion products.[13] In the latter case, as lead in sulfuric acid, silver in hydrochloric acid, or magnesium in hydrofluoric acid, the corrosion is stifled after a short active period by the corrosion product themselves, which form insoluble films on the metal surface, preventing access of the corrodants to the metal.[13] An interesting example of this occurs when steel is exposed to hydrogen chloride gas dissolved in perfectly dry benzene. Corrosion is inhibited by a thin film of metal chloride until a small amount of water is introduced into the system. Water dissolves the protective film and enables the hydrogen chloride to attack the metal.[33]

The possibility of forming protective films of corrosion products in many practical cases may at first glance seem remote, but in fact such films are known to be responsible for the protective action of a large class of inhibitors having extensive practical applications. The formation of a protective corrosion product film is not, in general, as simple as in the case of lead in sulfuric acid, and recourse must be had to the electrochemical theory of corrosion for a complete explanation.

According to the electrochemical theory, a corroding metal surface may be divided into elements such that either an oxidation or a reduction reaction, but not both, is in progress in the immediate neighborhood of each element. Those surface elements at which oxidation is occurring are called local anodes and those at which reduction is occurring are called local cathodes. In general, every element of a corroding metal surface is either a local anode or a local cathode, but none is both. Loss of metal occurs only at the local anodes, the metal there being oxidized to positive metal ions.

Since the oxidation of a metal involves the loss of electrons from the oxidized atoms, electrons are generated at the local anodes. At the local cathodes cations in the solution are reduced. For example, positive hydrogen ions may be reduced to form hydrogen gas. Reduction reactions require a source of electrons, which is provided by an electron current at the local cathodes across the metal-solution interface from the metal to the solution. An electron deficiency is then generated at the local cathodes and the electrical balance of the system is maintained by a transfer of electrons in the metal from the local anodes to the local cathodes, corresponding to an electric current in the metal flowing from the cathodes to the anodes.

Because corrosion occurs only at the local anodes it is possible to form a protective film of corrosion products only on the anodic areas of a metal surface and for this reason chemical agents that promote the formation of such films are known as anodic inhibitors. There is, of course, an electrostatic field in the neighborhood of every local anode because of the presence there of positively charged metal ions. This field corresponds to a potential difference between the anodes and the solution, and on that account negatively charged anions in the solution migrate to the anodes where they combine with the metal ions produced there. For example, if the solution contains sodium silicate, and if the corroding metal is iron, negative silicate ions migrate to the local anodes where they combine with ferrous ions to form insoluble ferrous silicate. If the ferrous silicate is formed immediately on the anode surfaces, and not in solution slightly removed from the metal surface, it has been found that the silicate forms a coating that is protective in some environments. The same applies to other insoluble anode reaction products. If, however, the anode reaction products are formed in solution, slightly removed from the metal surface, that is, if the anode reaction does not occur immediately on the formation of the metal ions, the anode films are in general not protective.[13]

The alkali chromates and dichromates are excellent anodic inhibitors for many applications. On a corroding steel surface, for example, the chromate (or dichromate) ions oxidize the ferrous ions produced at the anodes to ferric ions and precipitate a mixture of hydrous ferric and chromic oxides directly on the anode surfaces, where they form a protective film.[13] The alkali phosphates and carbonates may also form protective anodic films of metal phosphate or carbonate and are anodic inhibitors.

Cathodic as well as anodic reactions may give rise to corrosion inhibition and agents that enter into a cathodic reaction in such a manner as to decrease corrosion are known as cathodic inhibitors. Positive ions in solution, or cations, migrate to the local cathodes just as anions migrate to the local anodes. At the cathodes certain cations are reduced by the electrons leaving the metal, and if cations other than hydrogen ions are present in solution, they compete with the latter to be reduced. If the reduction potential of a particular cation is such that it remains in solution, and the hydrogen ions are reduced, then hydrogen gas is evolved at the cathodes, and the cation in question must exist in equilibrium with hydroxyl ions produced by the ionization of water.

If the metal hydroxide formed by the reaction of the cations and the hydroxyl ions is insoluble, a coating of the hydroxide will form on each local cathode,

chemically equivalent to the hydrogen that has been evolved. This coating may increase the electrical resistance at the cathodes, increase the hydrogen overvoltage, or produce other irreversible effects whose total effect is a back-electromotive force opposing the flow of electrons from the cathode surfaces. Such an effect is called polarization and it is because of the polarizing properties of the hydroxide film that the latter is protective. In order for corrosion to continue at the local anodes it is necessary for electrons to be transferred across the cathode surfaces and any interference with such transfer, polarization for example, decreases the corrosion rate. Zinc sulfate may act as a cathodic inhibitor.[37] Zinc ions in solution migrate to the local cathodes on a metal surface, but are not reduced there because the reduction potential of hydrogen exceeds that of zinc (at least in any environment of practical significance). Zinc hydroxide is, therefore, formed and deposited on the local cathodes, which it polarizes.

Polarization is not limited to the cathodes. Anodic inhibitors polarize the local anodes in the sense that they produce irreversible effects equivalent to a back-electromotive force opposing the formation of metal ions.

Oxygen promotes corrosion largely because it acts as a cathode depolarizer. The hydrogen formed at the local cathodes polarizes them, and oxygen by combining with the cathodic hydrogen depolarizes the local cathodes. Therefore, a cathodic film may also be protective if it decreases the rate at which oxygen can diffuse to the cathodic portions of a metal surface.

It should be reemphasized that to be protective a film must form immediately on a cathode or anode surface. If, for example, ferrous ions from a local anode, and hydroxyl ions from a local cathode both diffuse to some point and react to form ferrous hydroxide, and if then oxygen in solution reacts with the ferrous hydroxide to form ferric hydroxide, an insoluble film is laid down on the metal surface. However, this film, formed by a secondary reaction, is not in sufficiently intimate contact with the metal to be protective, and may actually increase the intensity of corrosion by forming oxygen concentration cells, which give rise to severe pitting.

On the other hand, if oxygen is present in solution in sufficient concentration that its rate of diffusion to the metal surface is great enough that the ferric ion is formed right on the local anodes, then ferric hydroxide is formed as the initial corrosion product and may be an effective anode polarizer.[13] Oxygen, then, may either promote or inhibit corrosion, depending on the circumstances. Unfortunately in practice it acts as a corrosion promoter much more often than as a corrosion inhibitor and its presence is usually undesirable. Oxygen has been used, however, to inhibit certain stainless steels in sulfuric acid, the steels being completely passive in the aerated acid although rapidly attacked by anaerobic sulfuric acid.

Salts of manganese, zinc, nickel, arsenic and antimony all may act as cathodic inhibitors, as may calcium salts in the presence of carbon dioxide provided the pH is properly adjusted. As a rule, cathodic inhibitors are not as effective as are anodic agents,[12] but are usually safe to use in any concentration. Anodic inhibitors include the alkali phosphates, carbonates and bicarbonates, chromates and dichromates, as well as sodium nitrite and some permanganates, tungstates and molybdates. These anodic agents are often very effective, and may give almost perfect protection in some applications.

If an anodic inhibitor is used in too low concentration, however, only a part of the total anodic area of a metal surface will be inhibited and the ratio of cathode area to anode area will be increased. It is well-known that a high cathode-to-anode area ratio is a necessary condition for the formation of pits and therefore the use of too low a concentration of an anodic agent may establish conditions favorable for serious pitting. For this reason anodic inhibitors are said to be dangerous.[13] Nevertheless, many of them are extremely effective in proper concentrations and they are widely used industrially. The presence of chloride ion in solution increases the danger of using anodic agents. This ion is small, and it can penetrate and disrupt an anodic film, destroying its protective action. While anodic inhibitors can sometimes be used in solutions containing chlorides, a higher concentraton is necessary than would be used were the latter not present. As has been pointed out by Evans, it is usually not good practice to treat a chloride-containing brine with alkalis, as is sometimes done. Corrosion has been observed at the edge of drops of 0.05 N sodium carbonate solution containing chlorides. The carbonates, being anodic agents, are of course dangerous in too low concentration even in the absence of chlorides. Evans[12] quotes a private communication from Mears citing a case in which sodium carbonate added to cooling water as a corrosion inhibitor was responsible for the rapid failure of a heat exchanger by pitting.

Other Theories of Inhibition. The theory just outlined is by no means the only one that has been advanced to explain the action of anodic and cathodic inhibitors.[22,38] One very interesting alternative is the electron configuration theory of Uhlig and Wulff,[38] which treats the question of passivity from the point of view of the work required to remove an electron from a metal atom. The electron configuration theory accounts for many of the observed phenomena of passivity and also explains the "critical concentrations" of certain alloying metals in steel required to increase substantially the corrosion resistance. Basically, this theory has much in common with the film theory, as do most of the other theories of corrosion inhibition and they all may represent different aspects of the same phenomenon. The electron configuration theory gives considerable insight into the mechanism of corrosion inhibition, but it not as comprehensive as the one given here.

Strictly speaking all corrosion is not of an electrochemical nature, but the exceptions to the electrochemical mechanism are infrequent and of little practical importance. An example of a reagent that will attack a metal directly without producing a flow

of electrons in the metal is hydrogen chloride gas in anhydrous chloroform, which attacks zinc vigorously although the conductivity of the solution is less than that of an equivalent air gap.[33]

Industrial Applications of Anodic and Cathodic Agents. Many of the anodic and cathodic inhibitors that have been discussed have practical applications, some very important. In 1945 sodium nitrite was used to inhibit 32 percent of all the petroleum product pipe lines in the United States.[39] The mechanism by which sodium nitrite protects steel is not known with certainty, but the nitrite is believed to form a metal oxide film that polarizes the local anodes.[39] Sodium nitrite can be used in as low a concentration as 0.005 percent in distilled water, while in sodium chloride solutions, the nitrite concentration necessary for inhibition is of the order of ten to fifteen percent of the sodium chloride concentration. The nitrite concentration required for pipe line protection, of course, varies with the nature and amount of brine in the line, but one pipe line has been successfully treated with 0.06 percent sodium nitrite in the water phase.[39] The protective action of this inhibitor falls off markedly in acid brines, but in more or less neutral solution it will inhibit steel, rusted steel and aluminum. It is used with alcohol and glycols in many commercial antifreeze compositions, usually in conjunction with other agents.

Permanganates are sometimes used to inhibit aluminum in carbonate and phosphate solutions. Their action is similar to that of sodium nitrite.[8]

The sulfates of zinc and manganese in 0.001 to 0.01 M solution in tap water have been used as inhibitors. These salts are cathode polarizers and deposite hydroxide and hydrous oxide films directly on the local cathodes. In general, protection increases with increasing inhibitor concentration, but despite the fact that these salts are cathodic agents and should be safe inhibitors, too high a concentration of zinc sulfate has been known to accelerate the corrosion of steel in water, particularly at the water line.[37] Nickel salts have also been used as cathodic agents on steel,[9] and under certain conditions it is to be expected that salts of cobalt, lead, mercury, silver, tin and uranium will act as cathodic inhibitors.

Zinc metal, incidentally, protects itself by forming a hydrous oxide coating on its own surface if the pH of the surrounding medium is 7.5 or greater and if the temperature is less than 60° C. If the pH is less than 6.5 the zinc is rapidly attacked.[4]

Arsenic compounds, arsenic trioxide and sodium arsenate in particular, inhibit the attack of sulfuric acid on steel. In a sense these arsenic compounds are cathodic inhibitors. No oxide or hydroxide film is formed, but arsenic metal plates out on the local cathodes, and increases the hydrogen overvoltage, which establishes protection. Antimony salts behave similarly in inhibiting the attack of hydrochloric acid on steel.[18]

The ammonium ion is reported to have some action as cathodic inhibitor.[27] It is known, in any event, that ammonia is more effective in treating corrosive oil wells than would be expected were its sole role the neutralization of the acid constituents of the well fluid. The mechanism has not been thoroughly established, but one investigator believes that the ammonium ion is adsorbed to the cathode surface where it serves to increase the hydrogen overvoltage.[27]

A number of alkalis—sodium hydroxide, sodium carbonate, sodium bicarbonate, sodium borate and calcium hydroxide, for example—are used as inhibitors. Alkalis are anodic agents and as has been explained, may be dangerous in too low concentration, particularly in salt water. Alkalis are used very extensively for corrosion inhibition in oil and gas wells. They are also used in boiler water treatment but here other factors than corrosion are also of importance in determining the treatment to be given a particular water. If much free hydroxyl ion is present in a boiler water, nitrates or tannin are usually added to prevent caustic cracking of the boiler.

The alkali phosphates, particularly the complex glassy phosphates, are especially good anodic inhibitors for steel because of the insolubility and high impermeability of the protective iron phosphate films formed on the local anodes. In treating a water system 0.1 to 100 ppm of glassy phosphate may be used but ordinarily 2 ppm will be sufficient except at high temperatures where the decomposition of phosphates is rapid. Excessive concentrations are required for protection in strongly acid solutions and the pH should be at least 6.0. Phosphates can be used to inhibit iron, steel, zinc, copper, brass and aluminum and for certain applications they are especially useful because of their ability to form complexes with many cations—calcium, magnesium and iron, for example—holding these ions in solution when they would otherwise be precipitated. Because of this complexing ability phosphates are often used in heat transfer systems, to combine corrosion protection with the maintenance of good heat transfer surfaces, and to prevent the formation of scales and sludges.[19] Phosphates are used in hot water tanks, boiler water treatment,[20] and in municipal water systems. In one case, 1 ppm phosphate in the water satisfactorily protected a city distribution system.[19] Phosphates have been used with borates as inhibitors in ethylene glycol type antifreezes, and there are other applications. The treatment of water with small amounts of phosphates (1-5 ppm) is usually called "Threshold Treatment," and there exists a very extensive literature on the subject.

The sodium silicates are anodic inhibitors that can be used with iron, steel, aluminum, zinc, copper, brass and lead. The protective film is a metal silicate in which hydroxides are probably also incorporated. Sodium silicate is not a simple compound in which the proportions of the constituent elements are invariant, and in the trade the composition is given as the ratio of Na_2O to SiO_2 content. The particular silicate that should be used in any application depends on the pH of the brine being treated.[36] The treated solution should not, of course, be too acid but then neither should it be too alkaline because excessively alkaline silicate solutions dissolve old corrosion products and form "red waters" if the cor-

rosion products are ferrous in nature.[36] In most cases about 28 ppm silicate as Na_2SiO_3 is sufficient to establish and maintain corrosion protection but the formation of the protective film is ordinarily slow. On steel a month is usually required.[36]

Sodium silicate is used to protect municipal water systems and is widely used to prevent lead poisoning in systems in which drinking water is transported through lead pipes. Silicates are also used extensively to treat hot water systems. Aluminum in phosphate and carbonate solutions is effectively inhibited by both silicates and fluorosilicates. Both are used as inhibitors in commercial aluminum cleaning solutions, many of which contain phosphates or carbonates.[8] Certain sodium silicates also inhibit aluminum in contact with organic bases and although it is difficult to inhibit aluminum in solutions of the alkali hydroxides, silicates are sometimes found to be effective in sufficiently high concentration.[8]

Certain colloids are also known that decrease the corrosion rate of aluminum in sodium hydroxide to as low as 20 percent of the rate in an uninhibited solution.[8] The mechanism will be discussed later.

Among the most widely used of all inorganic inhibitors are the chromates and dichromates. Chromates and dichromates always exist in equilibrium with each other in solution, the chromates predominating in alkaline solutions and the dichromates in acid solutions. Chromates can always be converted to dichromates by acidifying and dichromates to chromates by the reverse reaction. At a concentration corresponding to about 500 ppm Na_2CrO_4, a solution will contain essentially all chromate at a pH of 8.0, and all dichromate at pH 5.5. The chromates are ordinarily a little better inhibitors than the dichromates but the dichromates are cheaper. For this reason the usual commercial practice is to treat with dichromate and then to add enough alkali to effect the conversion to chromate.[7]

The chromates, as was explained earlier, owe their protective action to their ability to form an oxide film directly on the local anodes. Although chromate induced films have been studied extensively by X-ray and electron diffraction methods, little is known of their structure because of their extreme thinness, which makes the diffraction patterns difficult to interpret. The film on one piece of steel was found to be only three microns thick after twenty-two weeks' exposure of the metal in a chromate solution.[28] However, thin though they are, these films are normally hard, compact and impervious.

The concentration of chromate that must be used to treat any particular corrosive condition depends on the amount, nature and location of dissimilar metals, temperature, salt concentration, the ratio of metal surface area to volume of solution and possibly other factors. Salt concentration is particularly important because chromates in low concentration are dangerous inhibitors in the presence of chlorides. However, 500 ppm as Na_2CrO_4 is the concentration most frequently used for corrosion control in neutral solutions. Higher concentrations are often used and while lower concentrations may be practical in some cases, they may also be dangerous.[7]

When properly used the chromates are very good inhibitors, but they do not give perfect protection. Consequently, on steel, for example, ferrous ions are formed at a slow rate at the metal surface and converted to ferric oxide by the chromate inhibitor. Chromate is consumed in this reaction and for this reason the inhibitor is depleted at a slow but steady rate. Chromates in concentrations too low to effectively protect the metal are consumed at a much more rapid rate.[7] This is to be expected because all of the ferrous ions produced in the corrosion reaction will be oxidized by chromate as long as any is available and it is evident that high chromate consumption is unavoidable when the rate of formation of ferrous ions is high. The consumption of chromates is also very high in anaerobic acid solutions.[18]

Chromates are used to protect aluminum in sodium and calcium chloride solutions, in hydrochloric acid solution and in dilute nitric acid (less than 20 percent). One-half to one percent sodium chromate satisfactorily inhibits aluminum in phosphoric acid, depending on acid concentration and phosphoric acid so inhibited is used commercially as a cleaning and etching agent for that metal.[16] Aluminum is hard to inhibit in sulfuric acid but chromates have been used successfully in acid solutions stronger than 88 percent H_2SO_4, although they are of little value in the dilute acid.[23, 24] Aluminum is also afforded some protection in sulfuric acid by certain phenol-formaldehyde condensation products.[8]

Magnesium in saline solutions is inhibited by the alkali chromates, the chromate concentration necessary being about ten percent of that of the sodium chloride. Alkali and ammonium sulfides and fluorides are also used for this purpose, but the chromates are better inhibitors.[26]

Chromates are used with galvanized metals and are stated to be generally effective in systems in which a sacrificial metal is used to protect a structure, prolonging the lives both of the structure and of the sacrificial metal.[7] In the absence of specific data, however, this statement should be accepted cautiously. It is conceivable that in low concentrations chromate could protect a sacrificial metal without protecting the less anodic structure, the chromate being an anodic inhibitor. In such case the sacrificial metal would be robbed of its protective function; the structure would receive no protection at all, either from the chromate or from the supposedly sacrificial metal and corrosion of the structure would be accelerated rather than retarded.

It is in the protection of the ferrous metals that the chromates find their greatest application. They are used, for example, in air conditioning and refrigerating systems, automobile radiators, engine and compressor cooling systems; cooling systems for mercury arc rectifiers and furnace doors; in gas scrubbers, power plant condensers and stand-by boilers; in cooling water for hydro sand-blast equipment, in gas holders, quenching tanks, sprinkling systems and fire buckets;[7] in oil-well drilling muds and in the

protection of casing and production tubing in oil and gas wells. The amount of chromate used varies considerably with the application. A concentration of 250 ppm is usually adequate in gas engine and compressor cooling systems but up to 5000 ppm may be used in mercury arc rectifiers for example. In general, it is possible to use a lower concentration in systems in which the fluid is circulated than in static systems, because in such cases it is not necessary to rely on the diffusion of chromate to the metal surface to keep the anodic films in repair. In circulating systems it is also possible sometimes to reduce the chromate concentration after a steady state equilibrium has been established, the lower concentration being sufficient for the maintenance of the protective film, once formed. For example, in air conditioning systems 500 ppm chromate is usually maintained until the protective film is in equilibrium, any old corrosion products have been removed and the brine is clear yellow. Enough alkali is circulated to maintain the pH at about 8.5—slightly pink to phenolphthalein. Then after protection has been established, the treatment may be cut to about 300 ppm chromate at the same pH.[7]

The ice cans in refrigeration plants are usually made of galvanized steel and the rest of the brine circulating system may be galvanized or bare steel. The most common brines are twenty to twenty-five percent calcium or sodium chloride solutions. Following the recommendations of the American Society of Refrigerating Engineers[7] 1600 ppm sodium dichromate should be maintained in a calcium chloride brine and 3200 ppm in a sodium chloride brine. In either case the alkalinity is adjusted with caustic soda. The practice in some plants is to use a higher dichromate concentration, up to twenty-five percent greater than the ASRE recommendation, and it has been found that by so doing it is possible to achieve protection that is for all practical purposes perfect.[7]

One might suspect from the discussion thus far that under certain conditions almost any inorganic material may act as a corrosion inhibitor and this conclusion is not far from right. Oxygen has been shown to inhibit stainless steels in sulfuric acid and it is well known that aluminum is passivated by strong nitric acid although this reagent is violently corrosive to most metals. Even water has been used commercially as a corrosion inhibitor. Aluminum stills are used to distill fatty acids and it has been found that water added to the system decreases the corrosion of the aluminum considerably. The protective oxide coating originally present on the aluminum surfaces is attacked by fatty acids, and the function of the water is to keep this oxide film in repair.[7]

Organic Inhibitors. Organic as well as inorganic agents are used extensively as corrosion inhibitors. Formaldehyde has already been given as an example of a compound that reacts with another to form a protective film directly on a metal surface. Organic bases are sometimes used to remove corrosive acids from a system, although this is usually a prohibitively expensive operation unless the bases can be recovered and recycled. However, in the well-known Girbotol process for the sweetening of petroleum products, ethanolamine is used to separate hydrogen sulfide and carbon dioxide from hydrocarbons. The amine is recovered by heating to expel the acid gases. Organic as well as inorganic compounds can be used in general to react a corrosive agent out of solution. Pyrogallol, for example, might be used to remove traces of oxygen, although for most applications a cheaper inorganic reducing agent would probably be more practical.

Adsorption Inhibitors. At least two important methods of corrosion inhibition depend directly on the ability of certain organic compounds to concentrate at phase boundries, particularly by adsorption at solid-liquid interfaces. The first of these methods is applied to the protection of metals in acid solutions by the use of pickling inhibitors. In a pickling bath the organic inhibitor is adsorbed to the metal surface where it forms a film, at most a few molecules thick, which protects the metal by polarizing the local cathodes. The second method is applicable when a metal is in contact with two or more liquid phases, some corrosive, but at least one non-corrosive; for example, oil and a corrosive, aqueous brine. In such cases it is sometimes possible to add an organic inhibitor to the system that will adsorb to the appropriate interfaces, and so determine the free surface energies of the various phases that the metal will be completely wet by a non-corrosive liquid phase. To give a concrete example, by adding certain organic agents to oil, it is possible to make the oil displace water from a metal surface, and form a continuous film on the metal. This film effectively prevents the water from contacting the metal, and thereby protects it from corrosive attack by the water.

A polar molecule is a molecule that creates an electrostatic field in its immediate neighborhood because of the unsymmetric geometrical distribution of the elementary charged particles that make it up. Saturated hydrocarbons are not polar; but almost all other organic compounds are, to some degree, because of the effect of unsaturated groups and of atoms other than carbon and hydrogen on the electrical symmetry of the fundamental hydrocarbon structure.[21]

Nitrogen, oxygen and sulfur atoms have a very pronounced effect on the electrical symmetry of an organic molecule and such classes of compounds as the amines, amides, carboxylic acids, esters and organic sulfur compounds are strongly polar. Adsorption is primarily electrostatic in nature,[21] and for this reason strongly polar compounds are adsorbed to many metals and to interfaces in general. In particular, if certain polar compounds are present in a liquid contacting a metal surface, or a surface of corrosion products, they are adsorbed to the solid where they form a film in which the polar groups, i.e., the non-hydrocarbon portions of the molecules, are oriented towards the solid surface. The existence of such oriented films has been vertified by X-ray and electron diffraction investigations.[14]

The adsorption equilibrium of a large group of organic compounds, including the long chain (about 18 carbon atoms) fatty acids, alpha-hydroxy and alpha-halogen substituted fatty acids, esters, halides and nitriles has been very convincingly shown by Frewing[15] to be physical rather than chemical in nature, and reversible. However, chemical reactions may in some instances occur at the solid surface in the adsorption of such materials as the shorter chain fatty acids or the organic sulfides and in such cases chemi-sorption is said to take place. Either way the result is the same. An oriented film of organic molecules is present at the surface not more than a few molecules thick and probably a monolayer in many instances.

An entire solid surface is probably never covered by adsorbed molecules.[17] Polar molecules adsorb at certain points on a surface and between these "anchor points" other polar molecules are held by lateral attractive forces of the same order of magnitude as the primary adsorption forces. A network is thus formed that is anchored to the surface at a few points. If non-polar hydrocarbon molecules are present these may be trapped in the interstices and incorporated into a continuous organic film.[17]

Pickling Inhibitors. In the case of acid pickling inhibitors, no hydrocarbons are present and the entire protective film is composed of polar molecules. The electrostatic nature of adsorption notwithstanding it would be an oversimplification to assume that pickling inhibitors are adsorbed only at local cathodes. It is nevertheless generally believed that they owe their effectiveness to their ability to polarize the cathodic areas of a metal surface by increasing the hydrogen overvoltage and by increasing the electrical resistance at the local cathodes as well as by making access to cathodic surfaces difficult to depolarizers such as oxygen.[9] The cathodic polarization produced by a number of pickling inhibitors has been measured by Ardagh, Roome, and Owen[1] who found excellent correlation between the polarization produced by each of a number of organic agents and its effectiveness as an inhibitor. These investigators concluded from their work that low water solubility is necessary in a pickling inhibitor and that heterocyclic compounds with nitrogen in the ring are particularly good inhibitors, especially if certain side chains are attached directly to the nitrogen atom.

Rhodes and Kuhn[34] did some similar work and were able to correlate the effectiveness of various pickling agents with the increase in cathodic resistance caused by their adsorption.

Mann, Lauer, and Hultin[27] found that in general the greater the surface area "screened" by a single molecule of inhibitor, the more effective the inhibitor, in the sense that the molar concentration of agent necessary to achieve a given degree of corrosion protection is lower. These findings, however, probably represent a considerable oversimplification. Not only do other factors than the size and shape of a molecule determine the equilibrium adsorption on a solid surface corresponding to a given concentration in solution but the actual screening effect of a molecule depends on stereochemical relationships more complicated than the simple projection of its molecular area as assumed by Mann, Lauer, and Hultin.

There is in the literature[9, 10, 34] an enormous quantity of data relating to the effectiveness of various pickling inhibitors. Commercially on steel such materials as quinoline ethiodate, diorthotolyl thiourea, tannin, pyridine, yeast, molasses and industrial by-products as acid extracts from coal tar treatment, sulfonated slaughterhouse wastes, or sulfite wastes from paper mills have been used successfully. As mentioned earlier, cyclic materials with nitrogen in the ring are especially good.[1, 10] Acridine and substituted acridines,[34] ethyl iodide,[2] and *n*-tributyl, *n*-diaryl and *n*-triaryl amines[27] are all good pickling inhibitors. Some pickling inhibitors protect steel from embrittlement as well as from acid corrosion—pyridine or quinoline in two percent concentration, for example. Other agents, such as glue, inhibit corrosion only.[10]

Aluminum is inhibited in hydrochloric acid by alpha-phenyl acridine, acridine, beta-naphthal quinoline, and 2-phenylquinoline thiourea, all giving better than 97 percent protection in 0.003 M concentration. In phosphoric acid aluminum is inhibited by soluble oils, wetting agents and amines fairly satisfactorily. Steel pickling inhibitors are not as effective with aluminum in phosphoric acid as in hydrochloric.

Most organic inhibitors of the pickling type are effective only in fairly acid solutions. However, some quaternary ammonium compounds have been used very successfully in inhibiting steel in acid, neutral and alkaline waters.[3] These salts, like the pickling inhibitors are cationic agents and when used with sodium nitrite have been found effective in brines containing dissolved oxygen. Ordinarily 5 ppm of quaternary salt and 50 ppm sodium nitrite are sufficient. Quaternary ammonium compounds are used as inhibitors in water-injection wells in the secondary recovery of petroleum.

Other inhibitors of the general type that has just been discussed include heavy metal soaps, which inhibit steel in acetic acid,[18] and cyclohexylamine,[8] which is used to control corrosion in steam and condensate lines. Hydrophilic colloids have been used as acid pickling inhibitors.[9]

Oil-Wetting Agents. The preferential wetting type inhibitors discussed earlier have some practical applications. Oil wells, for example, may produce an oil phase, a gas phase made up of the lower hydrocarbons, carbon dioxide and hydrogen sulfide; and a brine saturated with the two acid gases and in which may be dissolved salts, organic acids and other compounds. In a producing well, heterogeneous fluids of this type are flowed through small diameter steel tubing, often at high velocity and under extreme temperature and pressure. It is therefore not surprising to find that the production tubing is frequently subject to a severe corrosive attack. A large number of organic inhibitors have been found that control tubing corrosion fairly well, and many of these owe their effectiveness to their ability to cause

the steel tubing to become oil wet.[35] In fact, it is known that many non-corrosive wells owe their inactivity to the presence in the well fluid of natural inhibitors of the oil-wetting type.

Oil containing agents of this type is sometimes added to heat exchanger water and to brines in various circulating systems to establish a protective oil film between the brine and the metal in the system. It is very necessary here that the oil actually wet the metal. If oil drops form on the metal making obtuse contact angles with the metal surface, oxygen concentration cells can be established between the open portions of the surface and the portions adjacent to the bases of the oil drops and pitting may result. Pits from this source have been observed in circulating water systems into which small amounts of oil were inadvertently allowed to leak.[11]

Special Applications. There are numbers of other special applications of organic corrosion additives. Organic inhibitors are added to crude oil and to refined petroleum products transported in pipe lines. Lubricating oils usually contain a number of organic additives including agents to prevent corrosion in bearings. These agents destroy the organic peroxides that are largely responsible for bearing corrosion, and may also destroy the catalytic effect of the bearing metals themselves in forming peroxides. Certain sulfur compounds act by forming a protective metal sulfide coating on the bearing surfaces. Lubricating oil additives are used in concentrations of from 0.1 to several percent, and include sulfurized hydrocarbons and esters, organic phosphorous compounds, aromatic amines and metal organic salts.[25]

Corrosion inhibitors are often added to cutting oils. Oil-water emulsions are sometimes used as coolants for cutting tools, and the emulsifying agents added may also act as corrosion inhibitors.

Oil wetting agents are sometimes used in slushing compounds.

Limitations of Chemical Treatment. In deciding whether or not to use inhibitors to control corrosion in a particular case, or in choosing an inhibitor, economics and chemistry are both important. Gold chloride can usually be eliminated from consideration as an inhibitor without difficulty and arsenic salts will never be popular additives in municipal water systems. A corrosion inhibitor is of no value in treating an oil well if it produces a tight water-oil emulsion. Again an agent may be an excellent pipe-line inhibitor for gasoline, but if it forms gums in engines it cannot be used. Nothing is gained by adding an inhibitor to a system from which it is immediately precipitated. Zinc sulfate will not remain in solution in water containing an excess of sodium sulfide, for example.

The effect of inhibitors on the operation of industrial processes is important. If an agent ruins heat transfer, or poisons catalysts, it is no good. On the other hand, process variables may affect inhibitor action. An agent that inhibits a single metal very effectively may be powerless to stop the corrosion of a galvanic couple including that same metal. Or if an inhibitor is to follow a product through several processes in which temperature, pressure, velocity, aeration, chemical environment, or surface area vary over wide limits, an extremely versatile agent will be required. Even old corrosion products may be important. An occasional car owner has discovered that his radiator had holes in it by adding an inhibitor to the radiator water that removed corrosion products that had very effectively been plugging the holes.

From an economic point of view, inhibitor cost, concentration and effectiveness, the possibility of recycling or recovering and rate of consumption are all important.

The conditions under which a particular inhibitor can be used may sometimes be quite critical. If carbonate, bicarbonate, and calcium ions are all present in a water solution, then under favorable conditions it is possible to form a protective coating of calcium and ferrous carbonates on the cathodic areas of steel in contact with the solution. If, however, the pH is too high, calcium carbonate will precipitate in bulk and may plug the system. On the other hand if the pH is too low, the protective carbonate film is redissolved in the solution.[4] This type of corrosion control depends on a very sensitive equilibrium but it is sometimes used. A similar film is formed naturally in some gas wells. Ferrous carbonate is deposited on the tubing surface and under favorable conditions it polarizes the local cathodes. But if the deposit becomes too thick, cracks in the film may develop because of mechanical stresses, and concentration cells may form which can cause serious pitting.[18]

Looking at the situation from a more cheerful point of view, the shortcomings of certain inhibitors can sometimes be overcome. It has recently been found, for example, that chromates in low concentrations are less dangerous inhibitors if they are used in conjunction with phosphates.[32] The protective film is principally ferric phosphate and the only function of the chromate is to oxidize the ferrous ions produced at the local anodes. In practice, one often has a rather wide choice of inhibitors and it is sometimes difficult to choose among them. The petroleum industry is currently treating oil and gas wells with caustic soda, soda ash, sodium bicarbonate, potassium carbonate, sodium chromate, sodium dichromate, sodium silicate, ammonia, formaldehyde and a rather large number of polar organic additives. Not all of these compounds are suitable for treating every well. Formaldehyde treatment is applicable only in certain wells that produce hydrogen sulfide and the alkalis and chromates have been known to plug wells producing a high calcium or magnesium brine. However, it is usually possible to treat a particular well with any of several agents.

Other Sources of Information. It has not been possible here to give an exhaustive list of the chemical agents that have been used in corrosion treatment, or of the commercial applications of each agent. The

chemical literature may be consulted with profit for more detailed information.

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Some Effects of Cathodic Protection On Conventional Paints*

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Abstract

The use of cathodic protection with metal protective paints is of interest to industry where steel structures are immersed in water or buried in soil. While both systems of protection offer many advantages, both have some disadvantages. Hence the question, "Are they compatible and would a combination of the two systems overcome some or all of the disadvantages of each?"

It was felt that with conventional paint systems, blistering could be minimized by applying a constant potential between an anode and the painted surface rather than a constant current. Four groups of tests were set up in fresh and salt water. Details of tests are given.

In fresh water it was noted that blistering of paint increased rapidly with increasing potential measured against the surface of the paint film with a saturated KCl calomel half cell. Although considerable blistering was observed where the potential measured against a calomel half cell did not exceed —850 millivolts, the paint films materially assisted cathodic protection.

In sea water it is also noted that vinyl paint films blistered increasingly with increasing potential pressure across the film. At potentials less than 1000 millivolts measured against a KCl calomel half cell very little if any blistering was encountered after 1½ years over that observed on a panel not under cathodic protection. On cathodically protected panels small pinpoint white deposits formed, indicating effective policing by cathodic protection.

To establish more definitely the best combination of cathodic protection and paint, the study should extend several years beyond the time of initial failure of the paint film.

THE USE of cathodic protection with metal protective paints and coatings is of interest to industry where steel structures are immersed in water or buried in soil. Both systems of metal protection individually offer many advantages. However, both systems possess some limitations. Hence the question, "Are they compatible and what conditions are required in a combination of the two systems to obtain the overall metal protection?"

Some practical considerations of this problem have been discussed by one of the authors in another paper.[1] It is the intent of this paper to describe and discuss observations made on painted steel panels and cylinders to which cathodic protection under controlled conditions has been applied in sea water and fresh water, respectively.

Most of the several thousand steel structures submerged in water to which cathodic protection is applied have been coated with one of a variety of underwater paints or coatings. Although nearly all these coatings assist cathodic protection in providing complete corrosion control, they have shown a susceptibility to degradation by electrolytic effects.[2]

Combination Protects Steel Pipe

Those concerned with the protection of buried steel pipe transmission and distribution lines have realized great advantage in the use of reinforced coatings with cathodic protection to assure complete corrosion control and lower current cost. This combination of the protective systems has proven to be good economically over long periods of time in protecting buried steel pipe upon which intense corrosion forces are exerted and which are not readily available for examination and repair.

Similarly, steel structures such as sprinkler and water storage tanks, clarifiers, dock piling, deep well pumps in contact with water are not always readily available for examination and repair.

For example, in the northern parts of the United States, ice formation often causes severe scoring of paint films on submerged surfaces of tanks. Because the most intense attack occurs during the hot summer months, it is necessary either to drain tanks each spring and at least patch the paint film or else to apply cathodic protection to attain more complete corrosion control. The latter step is easily applied without draining and losing use of the tank. The remaining paint film plays its part in limiting the area to be protected and the protective current required.

Along with the inhibitive effects of some pigments compounded in paints, an important physical property of these films is their ability to oppose the flow of current in the electrolytic corrosion process. This is more closely related to their resistance to permeation by moisture and electrolytes than to the ability of the dry film to conduct electrons. The significance of this property, which may be termed electrolytic resistance, in reducing corrosion and the amount of cathodic protection current required to assure complete corrosion control may be established by use of the electrochemical principles of corrosion and cathodic protection.

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** National Lead Company, Research Laboratories, Brooklyn, N. Y.

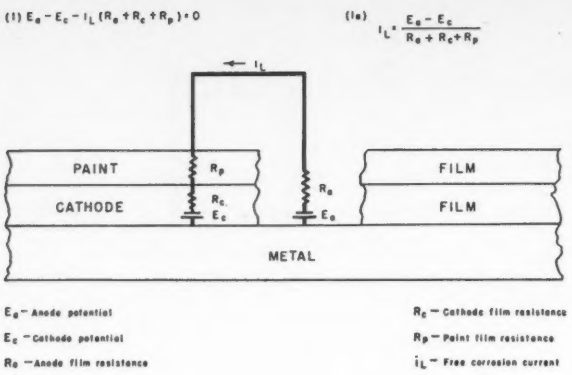

Figure 1—Free corrosion.

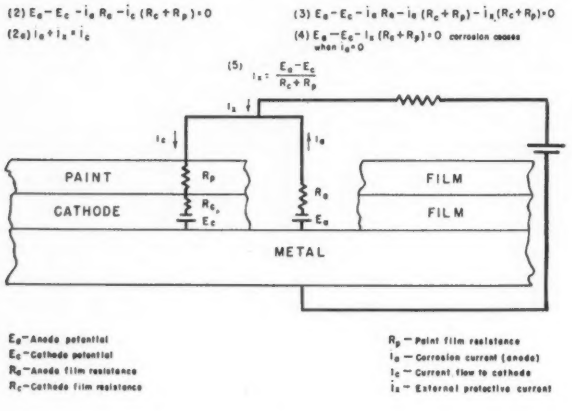
(2) $E_a - E_c - i_a R_a - i_c(R_c + R_p) = 0$
(2a) $i_a + i_x = i_c$
(3) $E_a - E_c - i_a R_a - i_a(R_c + R_p) - i_x(R_c + R_p) = 0$
(4) $E_a - E_c - i_x(R_c + R_p) = 0$ corrosion ceases when $i_a = 0$
(5) $i_x = \frac{E_a - E_c}{R_c + R_p}$
i_x
i_c
i_a
PAINT
CATHODE
FILM
FILM
METAL
R_p
R_c
E_c
R_a
E_a
E_a — Anode potential
E_c — Cathode potential
R_a — Anode film resistance
R_c — Cathode film resistance
R_p — Paint film resistance
i_a — Corrosion current (anode)
i_c — Current flow to cathode
i_x — External protective current

Figure 2—Cathodic protection.

A high paint film resistance (Rp) will greatly limit the value of the corrosion current (i_L). Similar treatment of a cathodicaly protected specimen, Figure 2, shows that the protective current i_x required to limit the anode corrosion current (i_a=0) can be greatly reduced by a high paint film resistance (Rp).

Effect of Relative Areas of Cathode and Anode

To visualize an instance of electrochemical corrosion, assume a coating on a metal surface with a scribed scratch line exposing an active metal area or else a pin hole flaw in the coating. In addition, to local action confined to the actual exposed metal area, the surrounding areas of metal on which the coating remains intact may act as a large cathode to the bare section. This has the effect of intensifying the penetration at the anode and may also contribute to deterioration of surrounding paint from accumulation of alkali and evolution of hydrogen. The extent to which this process can occur is limited by the degree of electrolytic conduction permitted by the paint film. If this is small, and provided the material of the paint film itself is not capable of acting as a cathode, then the corrosion will be restricted substantially to local action taking place on the bared area.

By the use of Kirchoff's law, the effect of coating resistance upon the flow of corrosion current in the freely corroding paint system is shown in Figure 1.

Another factor requiring much more rigorous treatment is the effect of paint films upon cathodic polarization. It is observed that as the paint film deteriorates its resistance decreases thereby allowing current to flow more readily. This results in the accumulation of cathodic product, causing a back EMF as distinguished from the IR drop usually included in overall polarization measurements.[3] This true polarization of the cathodic areas reduces the net potential differences over the metal surfaces, thus reducing the flow of corrosion current.

Deposits Limit Diffusion

Solid matter more or less uniformly covering the cathodic areas will retard diffusion outwards of the electrolytic cathodic products such as alkali, hydrogen, etc., and oppose the diffusion of depolarizing agents such as oxygen molecules from the bulk of the water. The better the diffusion layer, the less the protective current needed to maintain protective polarization. A paint film classified in poor condition by itself can materially reduce the protective current required for protection compared to that needed by a clean, bare metal surface.

After examining the properties of paint films in relation to cathodic protection current requirements the possible influence of the electrochemical forces and reactions upon the metal-paint system should be considered. Typical cathodic processes occurring on areas receiving current are:

1. $2H^+ + 2e \rightarrow 2H^\circ \rightarrow H_2$ ↑ Reduction of hydrogen ions
2. $O_2 + 2H_2O + 4e \rightarrow 4OH^-$ Reduction of molecular oxygen
3. $Fe^{+++} + e \rightarrow Fe^{++}$ Reduction of metal ions

These reducing processes are electrochemically equivalent to the current flow and the result of the first two processes is an increase in hydroxyl ion concentration and the accumulation of hydrogen. These reactions suggest that the effect of hydrogen gas evolution, alkali accumulation, metal ion reduction, etc., in any paint system used in conjunction with cathodic protection must be understood. In addition, water may be driven through the paint film under the influence of electro-osmotic forces.

Effects of Electroendosmosis.

These reactions also can occur on a painted metal surface in the absence of externally applied protective current as the result of corrosion currents resulting from non-uniform surface conditions. Kittelberger and Elm[4] have demonstrated the transport of water through paint films under the influence of an electrical potential gradient. They were able to establish a potential gradient by coupling a bare steel panel (anode) to a painted steel panel. In a series of panel tests using linseed oil paints with four different pigments, they noted the panels blistered badly in a few days in spite of the limited potential gradient developed by the couple used. Over 90 percent of the water absorption by the linseed oil type paints was caused by electroendosmosis.

In view of the conjugate considerations involved in the development of the best combination of paint

and cathodic protection systems, some panel tests have been conducted at the Sayville Marine Basin. Although necessarily preliminary, these tests have directed attention to significant factors which will provide a firmer basis for a subsequent investigation.

Initial Studies

Twelve 12 x 24 x ⅛-inch steel panels were set out in the first test for 96 days beginning September 3, 1948. Six panels were fully submerged and six were set at half tide. Of those at half tide, three panels were under cathodic protection and three duplicate panels were exposed without cathodic protection. The completely submerged panels were arranged similarly. The exposures in both cases consisted of a bare panel, a red lead vinyl system and a zinc chromate vinyl system. The completely submerged panels were given a coat of cuprous oxide antifouling paint.

An overall current density of 2 ma/sq. ft. was applied to the bare panel and 1 ma/sq. ft. to each of the painted panels in the tidal zone. A current density of 4 ma/sq. ft. was applied to the bare panel and 2 ma/sq. ft. to each of the painted panels in the submerged group.

On December 8, 1948, the panels were examined and a comparison of the cathodically protected and freely corroding panels was made.

In general, the cathodically protected painted panels in the tide range zone exhibited blistering. No blistering was observed on the panels to which no current was applied. The cathodically protected completely submerged painted panels exhibited no blistering but evidence of salt deposits at the edges and lead junctions was noted. No blistering was observed on panels not receiving current.

Although current applied to the bare panels was insufficient for complete protection weight loss measurement showed a reduction in the corrosion rate of the bare panels and no corrosion on the painted panels.

It was felt the duration of this test was too short and that some criterion other than constant current density would offer better control and make possible securing better results in a paint-cathode protection system. It was believed that some constant potential between anode and panel would permit self adjustment of the protective cathodic current as the requirements of the system changed with time of exposure and as a result of random factors causing mechanical damage to the film. This procedure would avoid the destructive effects of forcing an excess of current through an initially intact film and at the same time effect an economy of electric power.

On the basis of the initial study described above, further work was undertaken. This new test was divided into two parts, viz.:

1. Fresh water tests
2. Salt water tests

The duration of both tests was 17 months, April, 1949, to September, 1950.

Fresh Water Tests

The fresh water tests were conducted using seamless steel pipe sections (10 x 30 inches) closed at one end. The interiors of the pipe sections were sandblasted prior to painting. An aluminum anode was suspended in the center of each vertical pipe section. The entire assembly was connected with a power source and a rectifier as shown in Figure 3.

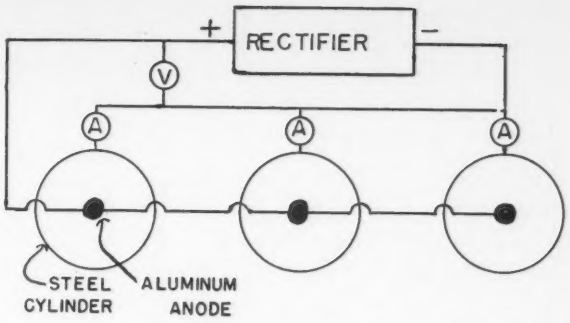

Figure 3—Fresh water tests.

The potentials applied were based on the potential between the anodes and the cylinders necessary to produce a current density on the unpainted steel cylinders which was sufficient for protection against corrosion, viz. 2.35 volts. In order to investigate the effects of different voltages, 0.1 times and 10 times this voltage were also used. The water in the cylinders was changed twice a week. Periodically, throughout the test the following measurements were made:

1. Current between anode and cylinder
2. Potential of the cathodically protected specimen to a saturated KCl-calomel electrode. The electrode was placed in close proximity to the surface of the painted cylinder.
3. The potential between the anode and the tank (applied potential).

From the applied potential and the measured current flow, the apparent resistance of the circuit could be calculated using Ohm's Law. While these values would not represent true electrical resistance, it was felt that changes in apparent resistance might reflect physical changes in the paint film. Misleading values of apparent resistance of the zinc dust-zinc oxide paint were noted as a result of the galvanic potential between zinc dust and the aluminum anode which tended to oppose current flow arising from the applied potential. Visual observations relative to the condition of the paint films also were made.

Salt Water Tests

Salt water tests were conducted using painted and unpainted sandblasted steel panels (12 x 12 inches). They were completely submerged at all times (even at low tide) and suitably connected with a power source, rectifier and steel anodes as shown in Figure 4.

The specimens were arranged in three groups and the potential applied between the anode and the panels was regulated by controlling the current density received by the bare specimen in the group. Because the possibility of mechanical damage to a paint film always exists, some of the painted panels

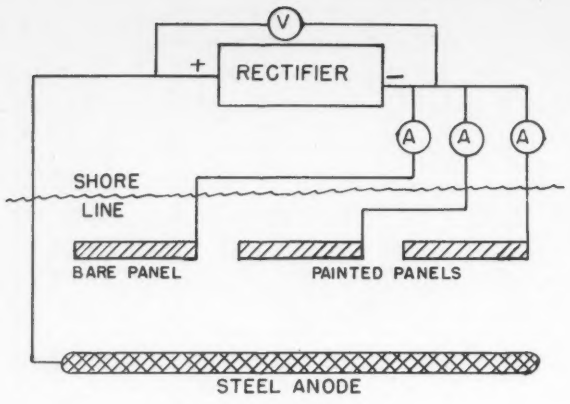

Figure 4—Salt water tests.

were scored (6-inch scores) through to the metal base with a sharp instrument. The potentials applied to the three groups of painted specimens were arrived at by establishing a current density of 1.5, 15.0 and a maximum of 410 milliamperes per square foot on the bare metal specimen of the respective groups.

The vinyl wash primers were about 0.2 to 0.3 mil thick. This was followed with 3 mils of vinyl anti-corrosive primer and 3 mils of vinyl antifouling paint.

Salinity, pH and temperature of the salt water was noted at weekly intervals. The salinity varied from 1.75 percent to 2.55 percent. The pH varied from 7.7 to 8.7. The temperature varied from 35 degrees F to 86 degrees F.

Test Data

Periodical electrical measurements and visual observations were made as in the fresh water test. A few examples of the values obtained in both tests are noted in Table I (Fresh Water) and Table II (Salt Water).

In many corrosion studies weight losses often are indicative and helpful in interpreting the data. In the fresh water-steel cylinder tests, no weight loss determinations were made because of the large initial mass of the specimens. In the salt water tests corrosion of all of the cathodically protected and painted panels during the exposure period was insufficient to produce significant weight losses whether or not cathodic protection was applied. Table III shows the weight losses of two unpainted specimens immersed in salt water for 19 months.

The comparison panels without cathodic protection remain on exposure in order to determine the effectiveness of the two paint systems involved. From the appearance of these panels, there is no reason to suspect that significant weight losses have occurred. Paint films of the cathodically protected panels were removed by sandblasting.

Weight losses of 10 grams or less were not considered significant due to the difficulty of removing the paint film without also taking away some of the steel.

Figures 5 to 12 inclusive are photographs of some of the salt water test panels with and without cathodic protection after 19 months' submersion. It

TABLE I—Fresh Water Tests

Exposed April 27, 1949 — **3½ Sq. Ft. in Contact with Water**

Cylinder No.	Type of Paint	Volts Between Anode & Tank			Current Between Anode & Tank			Millivolts Specimen to KCl Calomel Cell		
		1 Hour After Start	June 22, 1949	Sept. 28, 1950	1 Hour After Start	June 22, 1949	Sept. 28, 1950	1 Hour After Start	June 22, 1949	Sept. 28, 1950
4565	Red Lead—Linseed Oil	No Cathodic Protection						— 618	— 348	— 478
4566		2.35	2.8	2.7	14.5 microamps	7.8 milliamps	7.7 milliamps	—2015	—2400	—1000
4567		25.0	Discontinued		40.5 milliamps	Discontinued		Approx. —25000	Discontinued	
4568		0.25	0.32	0.29	0.5 microamps	93 microamps	0.36 milliamps	— 785	— 775	— 675
4569	Red Lead—Phenolic	No Cathodic Protection						— 460	— 372	— 280
4570		2.35	2.8	2.7	13.5 microamps	1.7 milliamps	7.57 milliamps	—2275	—3100	—1165
4571		25.0	Discontinued		2.0 milliamps	Discontinued		Approx. —25000	Discontinued	
4572		0.25	0.30	0.29	<1 microamps	68 microamps	0.26 milliamps	— 855	— 857	— 712
4573	Zinc Dust—Zinc Oxide	No Cathodic Protection						— 768	— 556	— 590
4574		2.35	2.8	2.7	10.5 milliamps	12.5 milliamps	7.98 milliamps	—1000	—1220	—1310
4575		25.0	Discontinued		160 milliamps	Discontinued		Approx. —25000	Discontinued	
4576		0.25	0.30	0.29	30 microamps	240* microamps negative	20 microamps	— 790	— 850	— 672
4577	Unpainted	No Cathodic Protection						— 632	— 725	— 482
4578	Unpainted	2.35	2.8	2.7	17.5 milliamps	12.3 milliamps	8.8 milliamps	— 645	— 935	—1005
4579	Unpainted	0.25	0.30	0.29	2.0 milliamps	0.44 milliamps	1.025 milliamps	— 550 to —610	— 706	— 552

* When cylinder 4576 was uncoupled and put on open circuit, the aluminum anode was —350 millivolts to KCl—calomel and the zinc dust paint was —870 millivolts to KCl—calomel. Thus, the zinc dust paint is anodic to the aluminum. The potential between the aluminum anode and the zinc dust measured to be 330 millivolts.

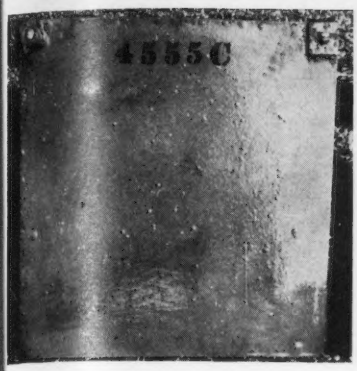

Figure 5—Painted panel on test 19 months. No cathodic protection.

Figure 6—Painted panel on test 19 months. No cathodic protection.

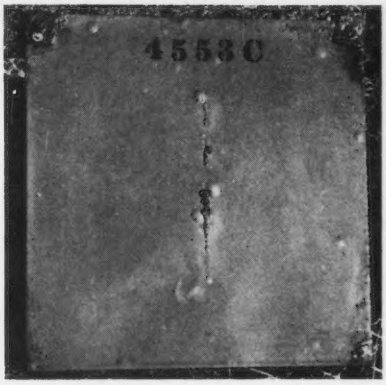

Figure 7—Scratched panel on test 19 months. No cathodic protection.

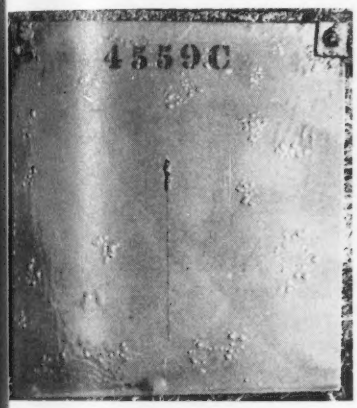

Figure 8—Scratched panel on test 19 months. No cathodic protection.

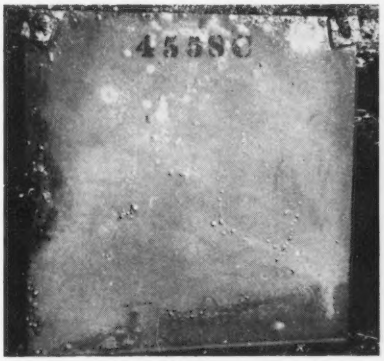

Figure 9—Painted panel on test 19 months. Cathodic protection (—917 to —1040 mv against saturated KCl-calomel).

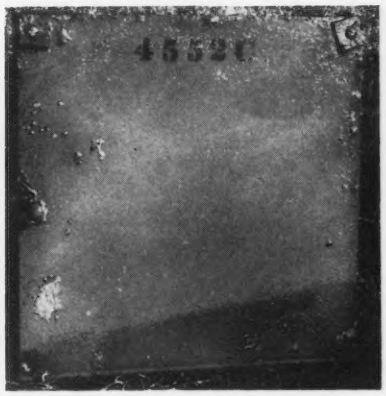

Figure 10—Painted panel on test 19 months. Cathodic protection (—918 to —1040 mv against saturated KCl-calomel).

TABLE II—Salt Water Tests

Exposed April 5, 1949 — 2 Sq. Ft. in Contact with Water

Panel No.	Paint Coating	Current in Amps. Anode to Specimen			Millivolts, Anode to Specimen			Millivolts, Specimen to Calomel Cell		
		April 27, 1949	June 22, 1949	Sept. 28, 1950	April 27, 1949	June 22, 1949	Sept. 28, 1950	April 27, 1949	June 22, 1949	Sept. 28, 1950
4562C	Unpainted	30×10^{-3}	25×10^{-3}	14.2×10^{-3}	602	650	1450	—1028	—1140	—1240
4556C	Basic $ZnCrO_4$	4×10^{-6}	325×10^{-6}	82×10^{-3}	650	650	1450	—1096	—1151	—1235
4550C	Pb Chromate	6.5×10^{-6}	400×10^{-6}	132×10^{-3}	650	650	1450	—1118	—1167	—1225
4554C	Basic $ZnCrO_4$ Scratched	18×10^{-6}	500×10^{-6}	152×10^{-3}	650	650	1450	—1135	—1212	—1235
4560C	Pb Chromate Scratched	17×10^{-6}	500×10^{-6}	80×10^{-3}	650	650	1450	—1140	—1198	—1235
4564C	Unpainted	3×10^{-3}	3×10^{-3}	5.3×10^{-3}	235	370	1040	— 405	— 905	—1040
4558C	Basic $ZnCrO_4$	1.8×10^{-6}	14×10^{-6}	280×10^{-6}	232	370	1040	— 615	— 917	—1040
4552C	Pb Chromate	1.2×10^{-6}	20×10^{-6}	1550×10^{-6}	235	370	1040	— 678	— 918	—1040
4563C	Unpainted	820×10^{-3}	0.43	37×10^{-3}	1046	940	1500	> —1400	—1280	—1260
4557C	Basic $ZnCrO_4$	22.5×10^{-3}	0.265	100×10^{-3}	1050	940	1500	> —1400	—1320	—1260
4551C	Pb Chromate	24×10^{-3}	0.150	150×10^{-3}	1049	940	1500	> —1400	—1420	—1240

PANELS WITHOUT CATHODIC PROTECTION

		April 27, 1949	June 22, 1949	Sept. 28, 1950
4561C	Unpainted	Very badly rusted.	Heavy fouling & rusting. Some pitting.	Heavy fouling, rusting, & rust nodules.
4553C	Basic $ZnCrO_4$ Scratched	Scattered rust nodules in scratch.	Blisters along scratch. Heavy corrosion in scratch.	Large blisters close to scratch. Rust nodules in scratch.
4559C	Pb Chromate Scratched	No corrosion in scratch.	No blisters along scratch. Slight corrosion in scratch.	Scattered patches of small blisters. Rust nodule in scratch.
4555C	Basic $ZnCrO_4$	No blistering or rusting.	No blisters, no rusting, no fouling.	Numerous blisters—pin point to $\frac{1}{8}$". No fouling.
4549C	Pb Chromate	No blistering or rusting.	No blisters, no rusting, no fouling.	A few large blisters ($\frac{1}{2}$") no fouling.

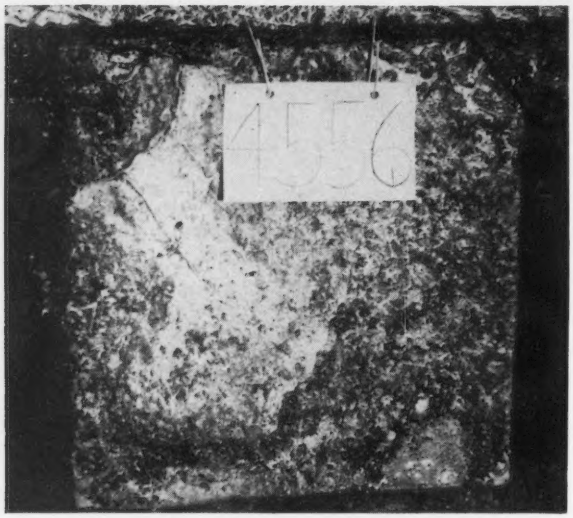

Figure 11—Painted panel on test 19 months. Cathodic protection (—1096 to —1235 mv against saturated KCl-calomel).

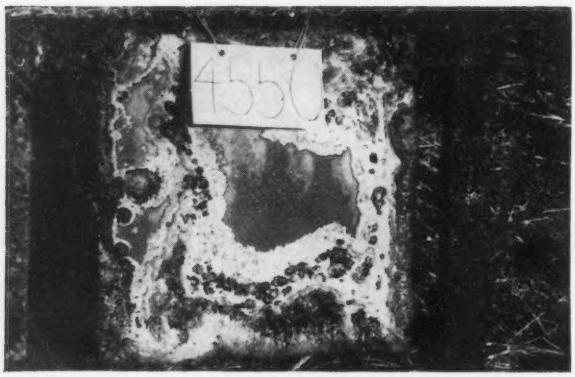

Figure 12—Painted panel on test 19 months. Cathodic protection (—1118 to —1225 mv against saturated KCl-calomel).

TABLE III

Panel Number	Original Weight of Steel Panel (Grams)	Loss of Metal in Grams
4561C	1980.0	268.8 (No cathodic protection)
4564C	1908.0	27.0 (1.5 milliamps/sq. ft.)

was noted that the paint blisters in the sea water tests were filled with gas. No liquid was evident.

Discussion

A study of Figures 5 to 12 offers a comparison of the paint conditions in the salt water tests on:

1. Freely submerged panels
2. Freely submerged panels with a scratch line
3. Cathodically protected panels whose potential was maintained from —615 to —1040 millivolts. Over the major portion of this period it varied from —917 to —1040 millivolts.
4. Cathodically protected panels whose potential was maintained between —1096 and —1236 millivolts throughout the test.

It will be noted that cathodically protected panels (Figures 9 and 10) whose potentials did not greatly exceed —1000 millivolts did not show any appreciable differences in blistering over panels in Figures 7 and 8. Whereas the paints on panels in Figures 11 and 12 whose potential had been maintained above —1100 millivolts were almost completely removed from the metal panels. Another comparison of Figures 7 and 8 with 9 and 10 indicates some corrosion activity at the scratch line, whereas salt deposits have occurred in the paint film breaks of the cathodically protected panels in Figures 9 and 10. Salt deposits of this type indicate the absence of corrosion activity. On cathodically protected panels, Figures 11 and 12, heavy salt deposits and fouling was noted with no evidence of active corrosion.

In applying cathodic protection to painted structures, it appears potentials employed should be just sufficient to establish protection to those areas of the structure where the paint alone can no longer prevent corrosion. Applied potentials much in excess of this will only accelerate paint failure. An accepted manifestation of protection of a bare metal structure receiving cathodic protection is that its true potential relative to a reference electrode is above a certain level corresponding to the open circuit potential of the freely corroding steel anode. Measurement of this potential can be of value in the controlled application of cathodic protection to painted steel surfaces. Under practical conditions, this criterion can be used wherever the paint has been thoroughly permeated by water and electrolytes, or where the paint has been locally removed in small areas by blistering and peeling or by mechanical damage. The observed potential of a newly exposed and completely painted structure would not be a reliable guide to the condition of the metal due to the effect of inhibitive pigments in passivating the metal surface, i.e., making the potential less electronegative. Under these conditions, the electrical stress across the paint film may be considerable if the open circuit potential of an active iron anode is used as a criterion for cathodic protection control.

It is now felt that the use of a constant potential between an auxiliary anode and the painted cathode for cathodic protection control is limited by variations of water conductivity and increasing anode resistance where a sacrificial type anode is used. An indication of the effect of paint coatings in reducing current requirements for polarization is obtained from examination of Table I (cylinders 4579, 4568, 4572; September 28, 1950, observation).

A suitable paint for use in conjunction with cathodic protection might be one differently formulated from those used in this study. Regardless of the formulation, such a paint should have

1. Good adhesion
2. Good water resistance
3. Good alkali resistance

Because formulations involved in this study were not selected specifically for outstanding properties in a particular category there remains an extensive field for study of this subject.

References

1. L. P. Sudrabin. Third Annual Varnish and Paint Symposium, New York University, 1950.
2. A. J. Eickhoff and D. L. Hawke. *Corrosion*, 7, No. 2, 70-74 (1951).
3. R. H. Brown and G. C. English. "Cathodic Protection." Symposium, Electrochemical Soc. and NACE, 7-11 (1949).
4. W. W. Kittelberger and A. C. Elm. *Ind. Eng. Chem.*, **37**, No. 7, 876-81 (1947).

Discussions

Literature Survey on Corrosion in Neutral Unaerated Oil Well Brines by Harry R. Copson. *Corrosion*, Vol. 7, 123-127 (1951) Apr.

Comment by F. A. Prange, Phillips Petroleum Co., Bartlesville, Okla.:

H. R. Copson's paper, "Literature Survey on Corrosion in Neutral Unaerated Oil Well Brines", concludes that the mechanism of corrosion in such brines is unexplained. There is another possibility still besides the ones discussed by Mr. Copson. There is reasonable doubt about the existence of corrosion in neutral unaerated brines. It is true enough that the brines as sampled and evaluated in the laboratory are neutral, but with the procedure generally used the brine has only a faint resemblance to the brine that did the corroding. Iron and some organic compounds have been oxidized, and the acid gas—the carbon dioxide and hydrogen sulfide—have been dissipated.

For a long time it was generally assumed that hydrogen sulfide was the corrosive agent that gave the most trouble and that when it was absent the corrosion was caused by a "corrosive sweet brine." In all cases of such corrosion I have investigated, there was appreciable carbon dioxide present. In fact, even when hydrogen sulfide is present, there is usually more carbon dioxide present, so that the simultaneous effect of carbon dioxide and hydrogen sulfide must be considered. It is the experience of Phillips Petroleum Company that carbon dioxide and hydrogen sulfide combined in gas produced by oil wells may be greater than even 40 percent. Of 24 gas analyses in 21 pools, 16 showed more carbon dioxide in the gas than hydrogen sulfide. While there are not enough data to confirm the idea, it seems that wells are not corrosive when the carbon dioxide content of the gas is less than twice the hydrogen sulfide content. A great deal of work done on distillate well corrosion, some published[1] and some unpublished, demonstrates that carbon dioxide dissolved in water and brine does cause corrosion. Thus, contrary to the findings ascribed to Watts by Copson, the work on corrosion in carbon dioxide solutions is so extensive that the corrosion must be considered real

Carlson[2] and others working on distillate well corrosion have demonstrated that the pH of the aerated brine has but little relation to the pH of the brine when exposed to an atmosphere of carbon dioxide. Generally, the brine will have a pH below 5.5 when subjected to carbon dioxide at a partial pressure of 20 psi or higher. Thus, practically all brines may be expected to allow hydrogen evolution when appreciable carbon dioxide is present, according to the hydrogen evolution point pH 5.4 cited by Copson. Of course, other factors like scale formation very markedly affect the corrosion rate. Of considerable interest are the data given by Carlson[3] showing the pH for plain sodium chloride brines.

The pH of Sodium Chloride Solutions Saturated with CO_2

Concentration of Parts Million of NaCl	PRESSURE OF CARBON DIOXIDE			
	20 psi.	40 psi.	60 psi.	80 psi.
100,000	4.3	4.1	3.9	3.7
10,000	4.2	3.9	3.8	3.7
1,000	4.1	3.8	3.7	3.6
100	3.9	3.7	3.6	3.4
0	3.8	3.6	3.5	3.4

From these data it is evident that in order to define the corrosive environment the partial pressure of the acid gas at the point where corrosion is occurring must be considered.

Visible hydrogen evolution is not required in acid type corrosion. Visible evolution means more hydrogen is produced than is required to saturate he fluid. When large quantities of fluid are circulated, as in the oil well tubing, considerable hydrogen could be removed without visible hydrogen evolution. Laboratory tests using only small amounts of fluid cannot be used as a criterion of corrosion in oil wells, particularly at the higher pH's.

In general, no definite evidence was produced that there is significant corrosion in neutral unaerated oil well brines.

1. C. K. Eilerts, Faye Greene, F. G. Archer, Betty Hanna, and L. M. Burman. "Alloying Steel for Corrosion Resistance to Gas-Condensate Fluid," *Corrosion*, **4**, Part 1, pp 245-263 (1948) June; Part 2, 321-357 (1948) July.
2. H. A. Carlson. "Corrosion in Natural Gas Condensate Wells," *Industrial & Engineering Chemistry*, **41**, 644-645 (1949) Mar.
3. H. A. Carlson. "The pH of Waters from Gas-Condensate Wells Saturated with Carbon Dioxide at Various Pressures," *Petroleum Engineer*, **17**, No. 2, 160-164 (1946) Nov.

Author's Reply:

Prange has emphasized more strongly than the paper the need of defining thoroughly and accurately the conditions under which corrosion is occurring. Such definition is a prerequisite for understanding any corrosion mechanism.

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Topic of the Month

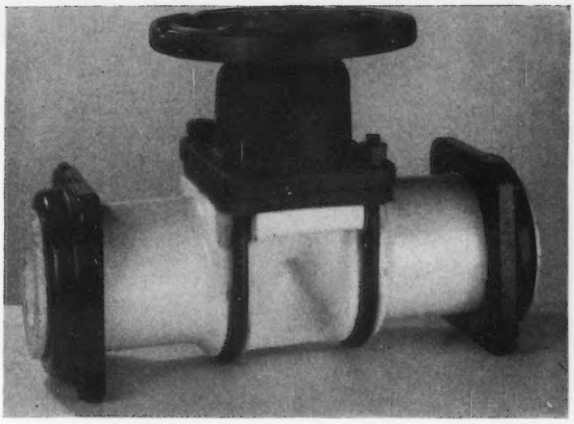

Figure 1—Ceramic bodied valve. (Photograph supplied by Lapp Insulator Company, LeRoy, New York.)

Ceramic Materials in Corrosive Service

By R. McFARLAND*

THE SCIENCE of ceramics is an old one and was in fact in the realm of an art for many centuries. However, within this century and particularly within the last ten to fifteen years, this science has been developed and expanded to produce techniques and types of ceramics to fit severe applications requiring inertness, strength, precision dimensions and utility, most of which developments have been due to requirements of the electronics, jet engine and atomic energy fields.

Because of the hardness, corrosion resistance and precision surfaces that can be produced these materials have found exceptionally wide application in fluid handling problems. For example, ceramic materials have now found successful application in reciprocating pump plungers, shaft sleeves, valve elements and inert facings for rotary seals.

These materials are now available in the form of complete ceramic valves of the plug type or diaphragm type (See Figure I), and in the form of ball check valves, pipe, fittings, cylindrical containers and odd shapes to fit special chemical applications. Fortunately, also, the fluorocarbon plastics such as Teflon and Kel-F constitute a companion piece in the form of valve packings, diaphragms and gasket materials for use in this fluid handling equipment.

These ceramic materials are usually made by either the wet or dry process, and the type of process utilized uses certain types of ceramic compositions applicable to these methods of manufacture. In the dry process, the material is pressed, dry, into shape and then these compacts constitute "green" pieces which can be subsequently formed in conventional machining operations, with the proper allowance for shrinkage, so that when subsequently fired in the neighborhood of 3000 degrees F., the piece vitrifies to a state of physical and chemical stability.

The pieces are then finished by grinding with diamond or corundum elements, and for fine finish surfaces they can be lapped or superfinished, and for certain applications can also be glazed by subsequent firing.

The wet process consists of pouring the "slip" into the mold around porous cores, which cores absorb the excess moisture and cause the "slip" to "set." Cores are subsequently removed and the "green" element dried at room temperature. Subsequent firing then produces the vitrified, physically and chemically stable piece.

Listed below is a table of average properties of ceramic materials:

Tensile Strength	8000 to 25,000 psi
Compressive Strength	65,000 to 300,000 psi
Flexural Strength	26,000 to 40,000 psi
Modulus of Elasticity	10,000,000 to 40,000,000 psi
Specific Gravity	2.5 to 3.63
Water Absorption	Zero
Hardness	7 to 9 (MOH Scale)
Coefficient of Linear Expansion	3.0 to 12.0 x 10^6

These materials are resistant to corrosives with only the exception of hydrofluoric acid, molten sodium and high concentrations of sodium hydroxide at boiling temperatures.

The material varies in resistance to thermal shock. Some formulations are not resistant while other formulations having some resistance.

These materials can be produced to exceptionally close dimensions, and with surface finishes of ten or less r.m.s. The material works exceptionally well on itself and thus permits the fabrication of intricate assemblies where the requirement calls for corrosion resistance and where the parts are also required to wear or bear on themselves without sticking or seizure.

A few of the applications for these materials are check valve balls, check valve seats, spray nozzles, pump liners, reciprocating pump plungers, wear plates, mixing valve parts, parts for electronic devices, insulators, etc. In many cases the cost of these parts are surprisingly low and often may be found to be competitive to or lower in price than metal parts for which they might be substituted. Also, the raw material supply is more than adequate for the foreseeable future and ceramic parts can, therefore, be procured when high alloy parts are unavailable due to metal shortages.

It is possible to produce ceramic parts with metal inserts and the versatility of bonding methods and cements usable with ceramics permits the metal-ceramic assembly to be used in stressed applications where both wear resistance and corrosion resistance are necessary. The photograph illustrates a diaphragm type valve now available with the ceramic body unarmored or armored with a high strength overlay of resin and glass fiber to give an assembly resistant to breakage and impact.

*Technical Director, Hills-McCanna Company, Chicago, Ill.

NACE News

Factors Other Than Salt Blamed Also in Automobile Corrosion

Discussion following the presentation of a paper on de-icing salt corrosion at Metropolitan Section's February 6 meeting indicated other significant factors in addition to de-icing salts are probably responsible for much automobile corrosion. Charles T. Roland of Calgon, Inc., Pittsburgh presented a paper entitled "The Corrosion Effects and Inhibition of Street De-Icing Salts," before nearly 90 members and guests including seven representatives of the newly-formed NACE Technical Practices Committee 19 on Corrosion by De-Icing Salts.

Pointing to the widespread use of sodium and calcium chlorides for melting snow, Mr. Roland said investigations of preventive measures in Akron and Rochester which included use of chromate and polyphosphate inhibitors showed protection of automobiles did not equal the approximately 80 percent indicated by alternate immersion tests. Tests are underway in the city of New York in areas where salt alone, inhibited salt and no salt are used to determine the extent of corrosion on vehicles in each. Test coupons also are being attached to underground transformers to determine the effect of salt on this equipment.

Newly elected officers of the section were installed as follows: Kempton H. Roll, chairman; George Hull, vice-chairman and F. J. LeFebvre, secretary-treasurer.

A film "A Winter Wonder," describing snow melting systems was shown through courtesy of A. M. Byers Company.

H. H. Uhlig, head of the corrosion laboratory at Massachusetts Institute of Technology will address the next meeting of Metropolitan Section on the evening of April 23. His topic will be corrosion problems. T. S. Zajac, Technical Practices Committee chairman, will review the work accomplished by NACE technical committees and T. P. May of International Nickel Co. will present the motion picture "Corrosion in Action."

Industrial Plant Corrosion Is Discussed

"Corrosion Problems in Industrial Plants," was discussed by J. M. Guthrie, of the research department of Union Switch and Signal Company, Swissvale, Pa. at the February 7 meeting of Pittsburgh Section. The evening meeting was held at Mellon Institute, Pittsburgh.

NACE MEETINGS CALENDAR

March

3—North Texas Section. Venus Restaurant. Dallas.

6—Pittsburgh Section. Bacteriological corrosion, speaker to be announced.

13—Detroit Section. Engineering Societies' Rockham Bldg., Detroit.

18—Houston Section. A.P. Farr, Hughes Tool Co., Houston, "Fatigue Corrosion in Drill Stems." Also Stanley C. Moore, Drill Collar Service Co., Midland, Texas, "Reducing the Corrosion Factor in Drill Stem Failures by Application of Cathodic Protection." A discussion from the floor by Oliver Osborn of Dow Chemical Co., Freeport, will follow.

18—Chicago Section. F. W. Pfohl of Armour Research Foundation, tentatively scheduled to speak on "The Mechanism of Corrosion Inhibition by Polar Organic Compounds."

25—Southwestern Ohio. Galvanic Corrosion and Related Materials, by Raymond B. Hoxeng, United States Steel Co. laboratory.

27—Sabine-Neches Section. At Port Arthur, Texas. Panel discussion, Lewis M. Nieliwocki, chairman.

April

3—Pittsburgh Section. Evaluation of Tapes as Protective Coatings, Carl Johnson, Minnesota Mining & Mfg. Co.

7—North Texas Section.

8—Houston Section. E. Q. Camp, Humble Oil and Refining Company, Baytown, "Graphite Precipitation-Migration in Low Pressure Atmospheric Temperature Refinery Vessels." Floor discussion, P. E. Darling, Pan American Refining Co., Texas City. An exhibit of specimens will be provided.

15—Chicago Section. Aaron Rabinkoff, Products Pipe Line Department, Standard Oil Company will speak on solution of internal corrosion of pipe lines of finished petroleum products by dehydration.

23—Metropolitan New York. H. H. Uhlig, Massachusetts Institute of Technology; T. Zajac, Shell Oil Company. Motion picture "Corrosion in Action," T. P. May, International Nickel Co., Inc.

26—Sabine-Neches Section. Field trip, Magnolia Petroleum Refinery, Beaumont, Texas.

29—Southwestern Ohio. "Industrial Waste," by Arthur Caster, Waste Disposal Engineer, City of Cincinnati, Ohio.

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Pages in the Corrosion Abstract Section of Corrosion are numbered serially in each volume so they may be bound by years with the annual index.

Uses of Neoprene As Maintenance Coating Described

Neoprene is now being supplied as a maintenance coating for exteriors of tanks and equipment for protection against splashed or spilled corrosives, corrosive fumes and atmospheres. This development is the result of a slightly modified neoprene polymer, which, before vulcanization produces solvent solutions of low viscosity per unit of solids content and from accelerators which will cure the polymer at room temperatures. This development was described to members of Greater St. Louis Section January 21 at its meeting at Forrest Park Hotel, St. Louis. L. S. Bake, of the E. I. DuPont de Nemours & Co. rubber laboratory, Deepwater, N.J. was the speaker.

Advantages of the film were given as: Excellent resistance to corrosives, sunlight and weather. A tough and rubbery coating with inherent resilience and a solids content of 60-70 percent, producing a thick film per coat which nevertheless brushes on readily. Ready curing at room temperature in 24 to 48 hours when an accelerator is added. A second coat may be applied in two or three hours after the first, and ready bonding of fresh coats to fully cured coats facilitates patching.

Disadvantages are the necessity for stirring in the accelerator just before using, giving a mixture with a 12 to 36 hour life, depending on the accelerator used. Surfaces must be thoroughly wired brushed or sandblasted, and then primed, with chlorinated rubber recommended. Colors other than black are obtainable only by sacifice of some chemical and abrasion resistance.

Petitions Approved

Petitions for recognition as sections of the National Association of Corrosion engineers have been approved by the officers and trustees of South Central Region as follows: Central Oklahoma and Teche.

Tulsa Officers Named

J. N. Hunter, Jr. of Service Pipe Line Co. was elected president, Jack P. Barrett of Stanolind Oil and Gas Co. vice-chairman and Ernest J. Liggett of Johns-Manville Sales Corp., secretary-treasurer of Tulsa Section. They took office January 31.

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Philadelphia Section Hears E. R. Shepard

E. R. Shepard, consultant to The Hinchman Corp., Detroit and Robert R. Pierce of Pennsylvania Salt Mfg. Co. were scheduled speakers at the February 8 meeting of Philadelphia Section. Mr. Shepard spoke on "Application of Cathodic Protection to Underground Utility Structures in Metropolitan Areas," and Mr. Pierce's topic was "General Fundamentals of Design and Material Selection in Corrosion Resistant Masonry." Mr. Pierce also was scheduled to show a motion picture illustrating examples of chemical brick construction.

Features of Rubber Base Paints Are Described To Detroit Section

Outstanding features of rubber-base paints for use in corrosive environments were described by Fred K. Shankweiler, Hercules Powder Company, Wilmington, Del. to 18 members and 13 guests of Detroit Section. The regular bimonthly meeting of the section was held January 17 at Engineering Society of Detroit's Rackham Building.

Mr. Shankweiler, supervisor of chlorinated products sales for Hercules, spoke on "Chlorinated Rubber Corrosion Resistant Coatings." He used a large number of colored slides to illustrate his remarks, showing controlled experimental test results with a wide variety of on-the-job applications of the materials in extremely corrosive environments. Charts and data presented indicated the steady increase in labor costs during the last few years has created a demand for corrosion-resistant coatings in instances where it formerly was the practice to paint every few years or several times a year. Savings in the cleaning cost preparatory to painting were surprising when projected over ten years compared to costs for identical areas of the same structure painted in traditional ways.

The intense attention of the audience evidenced in the question and answer session following the talk proved its high interest in this type of material.

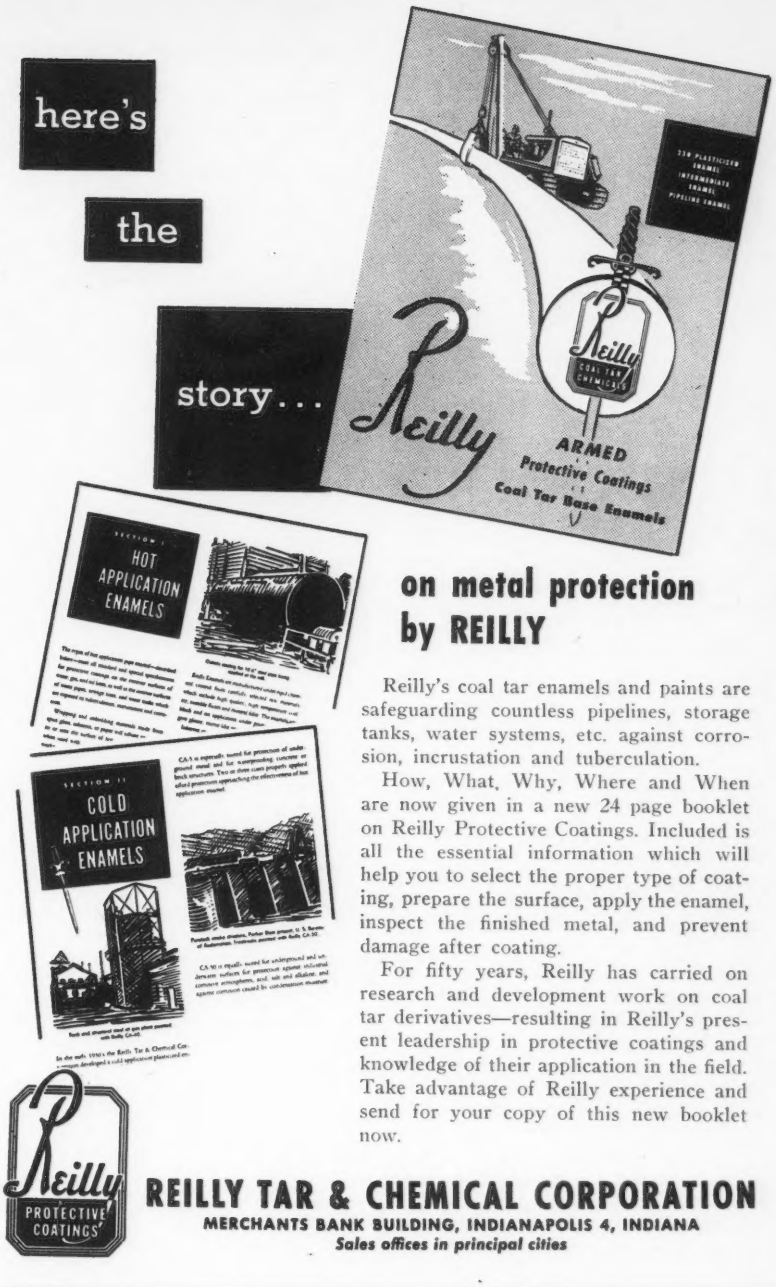
St. Louis Meetings

The dates and subjects of discussions at the three coming meetings of Greater St. Louis Section have been announced as follows:

March 17—Recent Developments in Metallizing, by Walter B. Meyer, Nooter Corp., St. Louis.

April 17—Ceramic Lined Equipment by S. W. McCann, Pfaudler Co., Rochester, N.Y. This is a joint meeting with AIChE and the Engineers Club.

May 19—Development and Application of Plastic Paints, by a representative of Dow Chemical Co., Midland, Mich.



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NACE POLICY ON DUES IN ARREARS

No member of the association with dues in arrears for three months shall receive publications of the association until such dues are paid. Members in arrears one year shall be dropped automatically from membership.

If your dues are not received at Central Office by the latter part of March, you will be dropped from the list to receive NACE publications and mail. Accordingly the March issue of CORROSION will be the last received by those so dropped.

In order to avoid interrupted mail and missed copies of CORROSION members are urged to remit dues before the deadline. Much work will be eliminated at Central Office if members remit before the date stipulated.

Broyles Speaks on Cathodic Protection At North Texas Meeting

Wayne Broyles of Brance-Krachy Co., Inc., Houston addressed members of North Texas Section February at a dinner meeting at The Broiler, North Main Street, Fort Worth. There were present 64 members and guests. His topic was "Cathodic Protection of Coated and Uncoated Steel Pipelines and Structures."

Sam Hodgton, vice president of Metal Goods Corp., Dallas showed a colored motion picture of offshore drilling structures in bays and in the Gulf of Mexico, emphasizing protective measures taken to protect the structures from corrosion.

Next regular meeting of the section will be held is scheduled March 3 at Venus Restaurant, Dallas.

H. L. Bilhartz, section chairman, who has been in South America, was present at the meeting.

Catalytic Treatment Is Topic at Corpus Christi

Ten members and ten guests heard Hank Stanley of the Sola Company talk on "Catalytic Treatment by the Sola Company" at a dinner meeting of Corpus Christi Section. The meeting was at Princess Louise Hotel, January 23.

Corrosion of Oil Well Drill Pipe Joints And Preventive Measures to Be Reviewed

Gribble Elected As Houston Section Head

Charles G. Gribble, Jr., Metal Goods Corp., Houston was elected chairman of Houston Section, February 13 at the annual joint meeting of the section with Houston University Junior Section. L. G. Sharpe of Humble Pipe Line Company was named vice-president and Gordon L. Doremus, of Cathodic Protection Service was elected secretary-treasurer. There was a capacity attendance of about 200 of whom about 60 were students from Houston University, Texas A. & M. and other schools.

Oliver Osborn, of Dow Chemical Company, Freeport was elected trustee and J. A. Caldwell of Humble Oil and Refining Company Houston Section's representative on the Houston Engineers' Council.

Fellowships Awarded

E. I. DuPont de Nemours Co., Inc. has authorized expenditure of $510,000 for the awarding of 75 post-graduate fellowships in 47 universities and grants-in-aid to other universities. The grants are unrestricted for use in the field of fundamental chemical research.

Full coverage of the subject of oil well drill pipe joint connections corrosion is scheduled for the March 18 meeting of Houston Section. A. P. Farr, field engineer for Hughes Tool Company, Houston will present the problem, explaining experience with failure of drill stem connections and evaluating the influence of corrosion on these failures. He will describe the apparatus with which the Hughes laboratories investigated the problem and show microphotographs of metals before and after failures, explaining what took place.

Stanley C. Moore of Drill Collar Service Company, Midland, Texas will present a discussion of "Drill Collar Failure" in which the fatigue corrosion factor in such failures is covered. He will describe how the application of cathodic protection to the steel helps minimize failures from corrosion. Specimens of failed collars and magnesium insert rings before and after use will be displayed.

Oliver Osborn of Dow Chemical Company, Freeport has been asked to provide the theoretical data describing the effect of the magnesium anodes to the metal.

The Hughes Tool Company also will provide a tour of its engineering laboratories and the section and its guests will have an evening meal at its cafeteria. The discussion will be held in the Hughes auditorium.

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San Francisco Bay Section Officers For 1952 Elected

Officers of San Francisco Bay Area Section were elected January 9 as follows: Richard S. Treseder, Shell Development Company, chairman; George A. Works, Union Oil Co. of Cal., vice-chairman; Charles E. Haney, Electric Steel Foundry, secretary-treasurer.

Dr. Aaron Wachter, head of the corrosion laboratory of Shell Development Company presented a paper on "The Relation of Corrosion to Business Costs" in which he pointed out acute corrosion problems are generally recognized while chronic ones are ignored.

Corrosion affects cost of production by impact on capital costs, sales and operation, maintenance and overhead. He cited an example of possible savings by saying that if corrosion could be eliminated on a certain 225-mile, 8-inch pipe line, wall thickness could be reduced from one-third to one-quarter inch, thereby saving 3700 tons of steel worth $500,000. In another instance he said the cost of bullheads replaced in a 12,500 ton tanker after seven years' use was $500,000.

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Technical material on corrosion will be considered by the NACE Editorial Review Committee from any source. Information on requirements of the association as to form of papers may be obtained on application to Central Office, Houston.

NACE offers a service consisting of abstracts printed on McBee punch cards cross-indexed according to the NACE Abstract Filing System Index on a subscription basis.

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"Corrosion In Action," New Inco Film to Be Shown at Galveston

"Corrosion in Action," the 60-minute sound and color motion picture produced by The International Nickel Co., Inc., New York, which will have its premiere showing at the NACE Galveston Conference on the morning of March 11, shows how corrosion works to cause six billion dollars annual loss. The film, in three parts of two reels each, is produced so it can be shown in parts or any combination of parts or in full length depending on time available.

Besides showing how corrosion causes damage the film shows how damage can be avoided or controlled through selection of materials, development of new materials, cathodic protection and many other methods. The film, which took about a year to produce, was made at the big testing station near Wilmington, N. C., at the new Harbor Island laboratory, in various industrial plants and elsewhere.

It was made essentially for showing to technical, educational and industrial groups, although its treatment is such it can be understood by non-technical audiences. It will be released for use in schools, colleges, industrial plants, and before technical societies after its March 11 premiere. Bookings can be made through the Corrosion Engineering Section, The International Nickel Co., Inc., 67 Wall Street, New York, 5, N.Y.

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25 Register for Houston University Course in Corrosion

Twenty-five have registered for the University of Houston corrosion course which started January 29 and will end June 6. Classes are held Tuesdays and Thursdays, 8 to 9:30 p.m. The course, being given by the university's engineering department under general supervision of Prof. J. R. Crump, in cooperation with South Central Region NACE, may be taken for credit or not for credit.

Instructors of the various sections have been listed as follows: I. Basic Principles as Required by the Corrosion Engineer. R. J. Rice, International Nickel Co., Inc., Houston. II. Basic Nature of Corrosion. Reactions from the Viewpoint of the Electrochemistry Involved. Adrian J. McAnneny. III. Protective Methods Other Than Electrical—Surface Coatings, Control of Environment and Selection of Materials. H. E. Waldrip, Gulf Oil Corp., Houston. IV. Cathodic Protection and Related Methods. Gordon L. Doremus, Houston.

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The annual index to technical material published in Corrosion, appearing in the December issue, consists of a topical cross-reference tabular index with author index and a tabular topical index to corrosion abstracts.

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University of California Corrosion Short Course Is Attended by 272

Registration at the University of California in Los Angeles' short course in Corrosion February 4-9 was 272. Of this number 43 were from states other than California and 42 from Los Angeles County. One-third of those registered were affiliated with the oil industry, while the aircraft, shipyard and municipal water industries were principal categories of other registrations.

Delaware University Has Corrosion Course At Graduate Level

A two-credit graduate course titled "Corrosion Theory and Prevention" is being given by the University of Delaware's Extension Division. The course, which began February 6 is offered by the Department of Chemical Engineering under direction of Dr. Lewis W. Gleekman, assistant professor of chemical engineering. Classes are being held Wednesday nights at Warner Junior High School for fifteen weeks. Registration is limited to 200.

The schedule of topics and speakers is as follows:

Feb. 13—Chemistry of Corrosion. R. B. Mears, Manager, Research and Development Lab., United States Steel Co.

Feb. 20—Fundamentals of Corrosion. Norman Hackerman, Professor of Chemistry, University of Texas.

Feb. 27—Corrosion Prevention in Copper and Copper Alloys. C. L. Bulow, Corrosion Metallurgist, Bridgeport Brass Company.

Mar. 5—Corrosion Testing Practice and Interpretation. F. L. LaQue, Corrosion Engineering Section, The International Nickel Co., Inc.

Mar. 12—Stress Corrosion. J. J. Harwood, Acting Head, Metallurgy Division, Office of Naval Research.

Mar. 19—Cathodic Protection—J. M. Pearson, Manager, Physical Laboratory, Research & Development Dept., Sun Oil Company.

Mar. 26—Prevention of Corrosion by Organic Linings. R. M. Burns, Chemical Director, Bell Telephone Laboratories.

Apr. 9—Corrosion Prevention by Lead and Alloys. G. O. Hiers, National Lead Co.

Apr. 16—Stainless Steels. W. B. DeLong, Engineering Experiment Station, du Pont Company.

Apr. 23—Surface Studies on Corrosion Behavior. N. A. Nielsen, Engineering Experiment Station, du Pont Company.

Apr. 30—Metal Coatings for Corrosion Resistance. Samuel Heiman, Chief Chemist, Phildelphia Rust-Proof Company.

May 7—Corrosion Resistance at High Temperatures. F. B. Foley, Consulting Metallurgist, International Nickel Co., Inc.

Nine of the twelve listed lecturers are members of NACE.

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The alternative measure, which was elected, is illustrated above. Without disturbing existing pipe, cable is ploughed in along the roadway to provide a bus from the rectifiers to which the anodes are connected. Power-driven earth augers drill vertical holes at intervals of 65 feet in which "National" Graphite Anodes are installed singly, surrounded by carbonaceous backfill. Connections are then made to the bus, after which the carefully tamped backfill is covered with earth, tamped and leveled. The result is a neat, unobtrusive installation, designed to give long life, effective, trouble-free cathodic protection.

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Abstract Card Service Booth Is Planned

One of the two booths assigned to the National Asociation of Corrosion Engineers during the Eighth Annual Conference and Exhibition at Galveston March 10-14 will be devoted to a display of the newly started Abstract Card Service. This interesting research aid, which has been under consideration by the association for several years, is subscribed to by 92 research engineers and libraries in this country and abroad.

It is expected that sample cards, copies of the guide to the service, sorting equipment, the plates used in the printing and other material in connection with the service will be on display. Mrs. Claudia Hayward, in charge of the service at Central Office, is expected to be present to answer questions.

Electrolytic Extraction Of Titanium Studied

Arthur J. Kerbecek, Jr., a graduate student of the School of Engineering, Columbia University has developed an electrolytic process for extraction of titanium, which, if proved commercially practical, may result in a substantial reduction in the price of titanium. Titanium produced by present processes costs between $6 and $12 a pound; quality steel sells for 60 cents a pound or less.

Zinc Institute Meeting

The 34th Annual Meeting of the American Zinc Institute will be held at Hotel Statler, St. Louis, Mo. April 21 and 22. Reports on the outlook for metals and the zinc supply, mine developments and several special features have been planned. The annual dinner and smoker will be held Monday evening, April 21.

NBS Symposium on Electrodeposition Attended by 200

A symposium on Electrodeposition Researches in Progress, the last of twelve symposia marking the Semicentennial of the National Bureau of Standards, was held December 4-6, 1951. Nearly 200 persons attended the sessions, at which reports were received from 22 industrial, educational, and governmental laboratories in the United States, England, France and Holland. The symposium, sponsored by the NBS in cooperation with the Office of Naval Research, was under the chairmanship of William Blum, chief of the NBS Electrodeposition Section.

George E. Gardam (Director of Research for the Gold, Silver and Jewelry Industries) opened the technical sessions with a report on English researches in progress. These include the electrodeposition of alloys of tin with zinc and of tin with nickel, chemical and electropolishing of metals, and the causes of porosity in electrodeposits. Jean Salauze (Société des Accumulateurs, France) described the principal electrodeposition studies in France on hard chromium plating, electropolishing and anodic oxidation of aluminum. Studies now being conducted in Holland on electroforming were discussed by P. Baeyens (Philips Gloeilampenfabrieken). The principal NBS electrodeposition researches, reported by William Blum, include electrodeposition of unusual metals from non-aqueous solutions, electroforming, electropolishing, thickness measurements and improvement of the surface properties of molybdenum.

At the second session, Charles L. Faust described the work at Battelle Memorial Institute on electroforming, and on deposition of alloys of chromium with iron and of zinc with tin and with manganese. A recently-developed self-regulating chromium bath and pyrophosphate baths for depositing copper and zinc were reported by J. E. Stareck (United Chromium, Inc.). O. C. Ralston (U. S. Bureau of Mines) described methods for the electrolytic recovery of zinc, manganese, cobalt, and chromium. Wm. H. Colner (Armour Research Foundation) discussed the foundation's investigations of plating on titanium, silver plating of wave-guides and deposition of magnetic nickel-cobalt alloys.

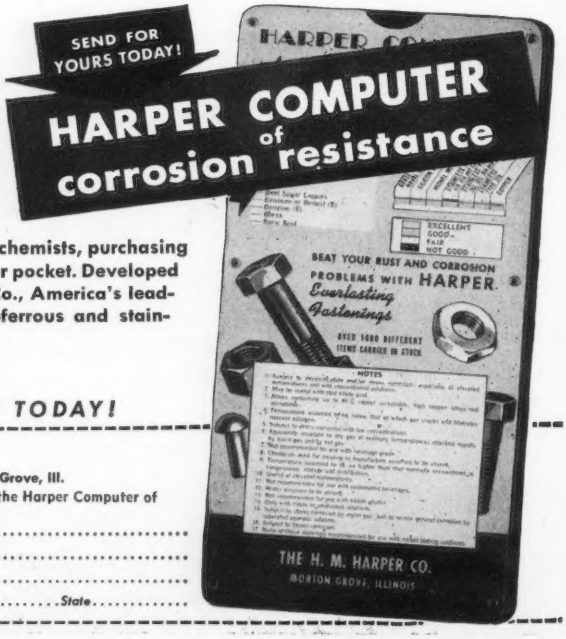
K. G. Compton and R. Ehrhart of the Bell Telephone Laboratories reported on the definition and control of a brass plating bath for producing deposits to secure adhesion of rubber to steel. The application of electroplated coatings in the construction of trimetal sleeve bearings used in aircraft and other high-duty engines were described by R. A. Schaefer (Cleveland Graphite Bronze Company).

The current research program of Enthone, Inc., as outlined by Walter R. Meyer, includes the study of conversion coatings on zinc, blackening of metals, chemical displacement coatings, oxide coatings, and methods of plating and of stripping coatings. M. R. Caldwell, L. B. Sperry, H. K. DeLong, and L. M. Morse described the joint research by the Doehler Jarvis Corporation, the Dow Chemical Company, and the Chrysler Corporation on the protective value of plated coatings on die castings of zinc, aluminum and magnesium. E. R. Bowerman stated that Sylvania Electric Products is studying methods of plating extremely fine wires and the deposition of tin-zinc alloys.

The final sessions of the symposium were devoted to several research projects now being conducted by the American Electroplaters' Society. Earl J. Serfass (Lehigh University) is studying methods of determining impurities in plating solutions and platings wastes while D. T. Ewing (Michigan State College) is investigating the effects of impurities in plating baths. The porosity and permeability of plated coatings is under study by N. Thon (Princeton University) and F. Ogburn (NBS). also at the NBS, A. Brenner and associates have just completed an extensive study of the physical properties of electrodeposited nickel. B. F. Dodge (Yale University) is currently studying the disposal of plating room wastes, including cyanides and chromic acid. J. Kronsbein (Evansville College) reported on his studies of current and metal distribution in electrodeposition, while H. B. Linford (Columbia University) described the methods being investigated for cleaning and preparing metals for plating.

Committee Meetings Program Is Prepared

Committee meetings to be held during the Eighth Annual Conference and Exhibition of NACE at Galveston March 10-14 will be printed on a schedule separate from the official program. Copies of the schedule may be included in the program when it is distributed and will be available separately as well.



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Corrosion Problems

E. A. TICE, Editor

Corrosion Engineering Section, The International Nickel Co., Inc., 67 Wall St., New York 5, N. Y.

Submit questions and answers for this column in duplicate to the editor. All questions become property of NACE. Questions and Answers may or may not be published under this heading, and may at discretion, be answered by mail directly. Answers to questions are solicited. Authors of questions will remain anonymous to readers while authors of answers may remain anonymous if they request it.

QUESTION

No. 12—(A) How can "bacterial" corrosion be identified: 1) to make certain that microorganisms are responsible; 2) to determine which types are responsible? (B) If microorganisms are responsible for the corrosion, what preventive measures can be recommended?

ANSWER

In order to definitely determine whether or not corrosion bacteria are responsible for certain types of corrosion, it is necessary to have a bacteriological examination of the soil or water in question. This examination will tell one whether or not the corrosion is due to bacteria and will identify the types of bacteria responsible.

Our own experience has been with steel pipe carrying water infested with these organisms. When this type of corrosion occurs, the inside walls of the pipe become covered with rust tubercules which are the result of colonies of the bacteria growing on the surface of the metal. The organisms in the colony die and their decomposition products, in conjunction with the formation of an oxygen concentration cell, set up a highly localized attack of the steel under the base of the tubercle. The tubercle formation is usually more pronounced as the velocity of the water through the pipe decreases.

These organisms fall into two main classes, namely, so-called "iron consuming" and "sulfate reducing." The former group generally consists of crenothrix, leptothrix, and others of the so-called capsulated species. When these organisms (iron consuming) are present, the corrosion which occurs is of the tuberculated or highly localized type. The tubercles when broken open have a foul algae-like odor. When the sulfate reducing bacteria (disulfuricans) are present, the corrosion is usually of a more general nature and a relatively continuous layer of ferrous sulfide builds up on the surface of the pipe wall.

In case of water the growth of both the "iron consuming" and "sulfate reducing" organisms can be controlled by chlorination of the water, preferably at the well. To obtain satisfactory control, the minimum chlorine residual should not be less than 0.5 ppm.—By Arba H. Thomas, Armco Steel Corp., Middletown, Ohio.

Editor's Note:

Readers interested in this problem are referred to Mr. Thomas' paper, "Role of Bacteria in the Corrosion of Iron and Steel" presented before the Second Annual Water Conference, November 3-4, 1941, Engineers Society of Western Pennsylvania, Civil Engineering Section.

QUESTION

No. 49—Can anyone cite cases of stress corrosion cracking of stainless steel used for heat exchanger service wherein hot brackish water is known to be the media causing the cracking?

ANSWER

Many of the refineries and chemical companies along the Gulf Coast report experiences with stress corrosion cracking in heat exchanger tubes wherein hot brackish water was the cause of stress corrosion cracking. Even where the water has been treated to reduce the chlorine content, cracking has continued to be a problem. Most of the operators hesitate to place a minimum value on the chloride content. Where the stresses are high, stress corrosion cracking has been experienced with very low chloride content. The stresses required to cause cracking can be very low. It does not require the high stresses such as those developed where tubes are rolled into a tube sheet. Only the slight bowing of tubes in service is sufficient to cause failure. In addition to stress and corrosion, some believe there is a third variable—temperature. It has been observed that stress corrosion takes place more rapidly at higher temperature. Cracks have been observed at the hot end of a tube but not at the cold end. In the same service, it has been reported that cracks developed in heat exchanger tubes where the maximum cooling water temperature was 175 F but not in the same system when the maximum temperature was dropped to 140 F. Stress corrosion cracking has been experienced in Types 304, 347, 316 and 317. It may develop somewhat faster in Type 304 than 316, but eventually might develop

(Continued on Page 12)

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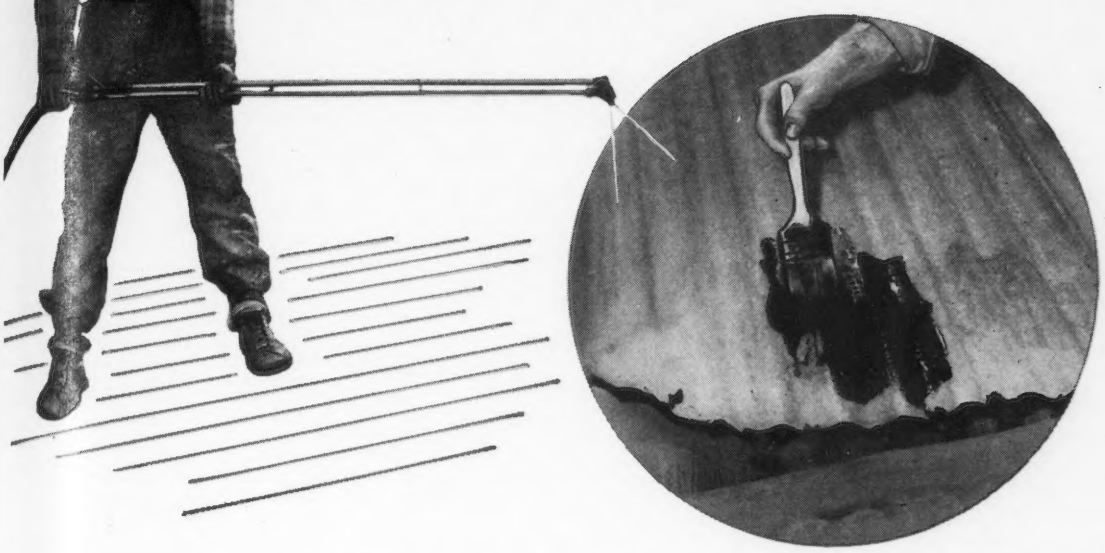

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Corrosion Problems—

(Continued from Page 10)

even in Type 316.—By M. E. Holmberg, Metallurgical Consultant, 4101 San Jacinto, Houston 4, Texas.

QUESTION

No. 76—In connection with the atmospheric corrosion resistance of zinc coated sheet steel is there any evidence available as to whether a hot dipped coating will last longer than an electro-plated coating of the same thickness? One theory has been stated that when the zinc coating corrodes down to the zinc-iron alloy layer on hot dipped sheet this layer corrodes at a lower rate than the zinc itself. Consequently, the hot dipped coating could be expected to last longer. If this is true, proportionally how much longer life can be expected?

ANSWER

In atmospheres that are polluted with sulfur fumes, the corrosion rate of zinc-iron alloy is practically the same as that of zinc. Therefore, a galvanized sheet with some of the zinc alloyed with iron will resist atmospheric attack slightly longer than a steel sheet electroplated with the same amount of zinc but whose total coating is less than that on the galvanized sheet because the coating on the galvanized sheet also contains some iron, which makes a thicker coating from a given amount of zinc.

In marine atmospheres or where chlorides are a major contaminant, the corrosion rate of zinc-iron alloy is 10 to 20 per cent less than the corrosion rate of zinc itself. This will tend to increase the effect noted above.

However, it is only under exceptional conditions of chloride pollution that a readily observable difference in the protection afforded by the two types of coatings will be noticed.

•

Requests for copies of Corrosion addressed to Central Office, Houston are filled (except when issues are exhausted) at the rate of 50 cents a copy for association members and 75 cents a copy for non-members.

Cathodic Protection Engineers Sought by City of San Diego, Cal.

The position of associate civil engineer (Cathodic Protection) with a salary range of $438 to $532 monthly is open with the city of San Diego, California. Applicants may apply at Room 453, Civic Center Building, where a civil service examination will be given. Among the prerequisites are: United States citizenry, residence in San Diego within 60 days after appointment, age 21-52, and education and experience equivalent to graduation from a college of engineering plus three years experience in cathodic protection engineering.

Quicker Write-Off of Waste Treatment Costs Proposed by Commission

A quicker write-off of costs incurred in the installation of waste treatment plants was recommended by the Ohio River Valley Water Sanitation Commission at its quarterly meeting in Cincinnati during the week of January 10. The commission also: Adopted sewage treatment requirements for the 150-mile Huntington-Cincinnati stretch of the Ohio River, authorized discussions with the U. S. Coast Guard leading to an inspection system to check pollution in the Ohio River, extended a contract with Kettering Laboratory of Applied Physiology for research on toxicity of substances in water, authorized $2000 for a fund to promote research into control of mine acids.

Tulsa Hears Anderson

H. H. Anderson of Shell Pipe Line Corp. addressed members of Tulsa Section at its January 31 meeting at Tulsa. His topic was "Why Industrial Management Should Promote Corrosion Control."

Aluminum's Advantages Explained by Verink

Thirteen economic advantages of aluminum as a material for use in the chemical and petroleum industries were described to members of San Francisco Bay Area Section February 5 at Alouette Restaurant, San Francisco. Fifty-one members and guests were present.

Ellis D. Verink of Aluminum Company of America, the speaker, illustrated his talk. Numerous applications where aluminum has proved more economical than more commonly used engineering materials were cited.

New ASTM Standards Have Been Published

New standard specifications announced by the American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa. are as follows:

Drying Oils, Protective Coatings: Tentative Methods of Testing Drying Oils (D 555 - 51 T). Replacing previous ASTM Methods D 555 - 47 T, D 553 - 50 T and D 967 - 48 T and including pertinent sections from other related methods.

Method for Measurement of Dry Film Thickness of Non-Magnetic Coatings of Paint, Varnish, Lacquer, and Related Products Applied on a Magnetic Base. (D 1186 - 51 T) Magnetic Gauge Methods. Supplements Tentative Method of Test for Measurement of Dry Film Thickness of Paint, etc. (D 1005 - 49 T).

Tentative Specifications for Asphalt Base Emulsions for Use as Protective Coatings for Metal (D 1187 - 51 T). Largely a performance type specification but includes general requirements for composition. Methods of test for these materials were completed in 1949 and were issued under designation D 1010 - 49 T.

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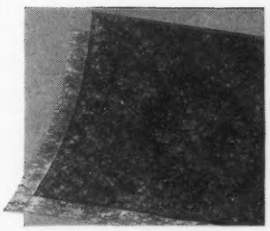

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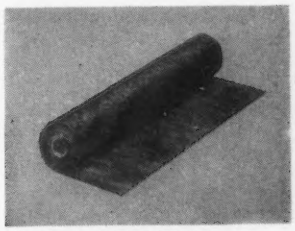

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Five Papers at ASM Pittsburgh Meeting Relate to Corrosion

Five of the papers presented at the American Society for Metals Midwinter Meeting at William Penn Hotel, Pittsburgh January 31-February 1 are of corrosion interest. Symposia presented were: Titanium and Titanium Alloys, Embrittlement, High Temperatures and Oxidation, Nonferrous Alloys and Transformations and Grain Growth.

Following are brief summaries of information from the five papers:

The Scaling of Titanium in Air by P. H. Morton and W. M. Baldwin, Jr., Case Institute of Technology, Cleveland: Steps in observing and interpreting corrosive effects on titanium sheet through the study of colors in oxidation are described. The metal is reactive to both oxygen and nitrogen and has a tendency to scale rapidly when exposed to air. Different temperatures produce wide variances in color tones; below 1562 degrees a light colored scale becomes light blue, and in turn mottled, took on a yellow coloration and finally turned brown.

The Rate of Pickling Test for Tin Plate Steels and Its Metallurgical Significance by E. L. Koehler, Armour Research Foundation, Chicago: Low internal resistance of basis metal used for fabrication of tin cans or basis metal which has been improperly treated will result in spoiled food. Grain boundary oxides in surface layers of the steel developed during box annealing in a furnace atmosphere not oxidizing to ferrite grains but oxidizing to grain boundaries only were blamed for the failures.

Accelerated Oxidation of Metals at High Temperatures by A. Brasunas, Oak Ridge National Laboratory, Oak Ridge, Tenn. and N. J. Grant, Massachusetts Institute of Technology, Cambridge, Mass.: Accelerated oxidation of nickel-chromium-iron alloys to which molybdenum or vanadium has been added can be reduced if the nickel content is increased. A jet engine alloy, for example with a normal 25 percent nickel content is increased to 40 percent nickel. The relative amount of chromium is decreased.

Effects of High Temperatures and Oxidation Atmospheres Upon Inconel by T. E. Piper, Northrop Aircraft, Inc., Hawthorne, Cal.: Tests to determine the chemical and mechanical characteristics of Inconel used in jet engine flame tubes showed heat scale previously believed keyed into bare metal was not securely attached at all. The refractory character of the scale was considered to be due to molecular structure rather than to the manner of attachment. A search is underway for a cleaning agent to remove the scale because severe corrosion occurs when presently available agents are used.

Recrystallization and Grain Growth of Nickel by G. W. Wensch, Fansteel Metallurgical Corp., North Chicago and H. L. Walker, University of Illinois, Urbana: Molecular groups or crystals in commercial-purity nickel can be recrystallized (regrouped) by specified amounts of cold rolling and isothermal annealing with time as the variable. The more the metal is worked in the cold rolling process the less heat is required to effect recrystallization.

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Ways of Protecting Chromium on Autos Given by Electroplaters

Suggestions for protecting bright chromium plate on automobiles from corrosion, especially from deposits of street de-icing salts are given as follows by the American Electroplaters' Society: Frequent washings. Occasional applications of a light lubricating oil, about 10 W. Wax body finishes help but are not as effective as oil.

Plating already damaged should be rubbed with a mild scouring powder and oil applied to the cleaned surface.

Additional care in protecting chromium plated parts is recommended because of the thinner platings being used now as a result of metal shortages.

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The Inter-Society Corrosion Committee provides a means whereby organizations engaged in corrosion research may correlate their efforts to avoid duplication of effort.

Questions for NACE Round Tables Collected

Questions for the Pipe Line and Underground Corrosion and the General Corrosion Problems Round Tables are being collected, edited and prepared for reproduction by the chairmen of the discussions, Kirk H. Logan and R. B. Hoxeng. These reproduced questions are expected to be made available to those attending the discussions which begin at 9 a.m. Friday, March 14 at Galveston during the Eighth Annual Conference and Exhibition.

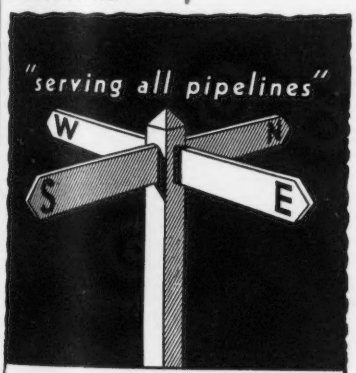
Accelerated Corrosion Test Reports Expected At Galvanizers Meeting

Some results of accelerated corrosion tests being conducted by the Quality Control Committee of the American Hot Dip Galvanizers Association, Inc., are expected to be revealed at the March 24-25 meeting of the association at the Drake Hotel, Chicago.

Two hot dip galvanizing plants will be visited by association members March 25—those of the Joslyn Manufacturing and Supply Co. and the Equipment Steel Products Company.

Bruce D. Owen Elected

Bruce D. Owen, Telephone Building, Oklahoma City has been elected by officers of Central Oklahoma Section to fill the office of secretary-treasurer of the section for the remainder of 1952. This action was taken because of the illness of LeRoy J. Vaneigh, formerly secretary-treasurer, who has been unable to act because of illness.



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REPRINTS

Cathodic Protection and Pipe Lines

A Proposed Standard Method for Measuring the Electrical Resistance of Pipe Line Coatings by W. F. Rogers, B. H. Davis, Lyle Sheppard, Donald Bond, L. G. Sharpe, E. R. Allen and P. T. Miller.

Utilization of Electrically Insulated Couplings in Corrosion Control by W. F. Levert.

Mitigation of Corrosion on City Gas Distribution Systems by A. D. Simpson, Jr.

Paints and Coatings

The Effectiveness of Paint in Suppressing Galvanic Corrosion by G. W. Seagren, G. H. Young and F. L. LaQue.

Tests, Properties of Corrosion Preventive Lubricants for Lead Sheathed Cables in Underground Ducts—A Discussion by Howard S. Phelps and Frank Kahn.

Petroleum Production and Storage

Corrosion in Condensate and in High Pressure Sweet Oil Wells by R. C. Buchan.

The Use of Ammonia in Control of Vapor Zone Corrosion of Storage Tanks by F. T. Gardner, A. T. Clothier and F. Coryell.

Miscellaneous

Causes of Corrosion in Airplanes and Methods of Prevention by N. H. Simpson.

Cathodic Protection of an Active Ship in Sea Water by K. N. Barnard and G. L. Christie.

Corrosion of 18-8 Alloy Furnace Tubes in High-Temperature Vapor Phase Cracking Service by E. Q. Camp, Cecil Phillips and Lewis Gross.

Salt Spray Testing Bibliography by Lorraine Voight.

The Cost of Corrosion to the United States by H. H. Uhlig.

Why Metals Corrode by H. H. Uhlig.

Reprints of Technical Practices Committee Reports

Report of TP-12 on Electrical Grounding Practices.

First Interim Report of TP-6G on Surface Preparation of Organic Coatings. Publication 50-5.

Stress Corrosion Cracking in Alkaline Solutions. Report of TP 5 C—Sub-Surface Corrosion by Alkaline Solutions. Publication 51-3.

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British Estimate Corrosion Loss in U. K. To Underground Pipe at $130,000,000

Annual cost of replacing corroded underground pipe in Britain is about $130,000,000 annually it was estimated by speakers at a Symposium on the Corrosion of Buried Metals at London December 12. Attendance of 330 delegates was reported by the British Iron and Steel Research Association and the Corrosion Group of the Society of Chemical Industry, joint sponsors of the symposium.

Sir Charles Goodeve, chairman of the symposium said some 100,000 miles of buried pipe were under risk in 1949 and that another 25,000 miles of mains are under consideration.

Six papers designed to present a general review of existing knowledge on the subject were presented, each being followed by discussions.

Reporting on the events leading to the first paper presented, Dr. J. C. Hudson, head of the Corrosion Laboratory, British Iron and Steel Research Association said three sets of steel and cast iron specimens covering a wide range of bare and coated pipe were buried in diverse soils in 1944. For bare pipes differences in aggressiveness of the soils were more important than differences in material. It appeared also that previously reported differences in the resistance of spun and cast iron pipe had been due rather to differences in wall thickness than any other factor, the spun type being up to one-third thinner for equal mechanical properties.

Following are extracts of the papers and discussions following them:

Tests on the Corrosion of Buried Iron and Steel Pipes by J. C. Hudson and G. P. Acock and **Investigations on Underground Corrosion** by K. R. Butlin, W. H. J. Vernon and L. C. Whiskin. First paper recapitulated work since 1934 dealing with sulfate-reducing bacteria confirming the conclusions of Dutch investigators on the part played by vibrio desulphuricans. Field investigations in collaboration with the Institution of Water Engineers showed corrosion associated with sulfate-reducing bacteria most widespread and dangerous form of underground corrosion.

Second paper described experiments in protection of ferrous pipes at Chigwell in collaboration with the Metropolitan Water Board. Microbiological corrosion has been known to occur in situations similar to those at Chigwell in 12 months and commonly within 10 years. Large scale tests there showed mains protected with standard 0.0005-inch hot-dip coal tar enamel (Angus Smith solution) were badly graphitied after three years. A 3/8-inch bitumen coating however gave adequate protection as did backfill of good quality concrete or gravel.

Discussion: Values of tests on short lengths of pipe was questioned. W. G. Waite said he believed too much stress had been laid on bacteria and that more stress should be on cell corrosion that started it. He expressed surprise no attempt was made to use cathodic protection at Chigwell. Dr. Vernon, in reply, asserted microbiological corrosion was not basically different from electrochemical corrosion of which it was merely a special type, however, he said, a very great majority of pipeline failures in Britain have been associated with unmistakable symptoms of microbiological influences.

Cathodic Protection by K. A. Spencer and **Cathodic Protection of Buried Metal Structures** by R. de Brouwer. The first paper dealt with the techniques of applying cathodic protection, in the course of which the opinion was reiterated that anaerobic conditions were the chief cause of underground corrosion in the United Kingdom. The corrosion of metals underground is associated with a positive electrical current flow from the metal to the electrolyte at the anode—the point of corrosion. Mr. De Brouwer's paper dealt with cathodic protection by polarized drainage and forced drainage the distinction being in the method of application.

Discussion: In France no main is laid today before apparent and specific aggressivity of the soil is measured. Ultrasonics are being considered as a means of controlling sulfate reducing bacteria. H. C. S. Hayes of the General Post Office said the post office had some 35,000 miles of main trunk cable in which 1000 sheath faults occurred in 1950 due to corrosion. Some 3000 faults occurred on shorter cables due to corrosion. Of 6000 exchange central areas 45 percent have been affected by corrosion at one time or another. Practically all cables are laid bare in earthenware pipes and only 5 percent have a protective covering over the lead sheath.

Cable protected with hessian tape and compound was found to be completely protected except from mechanical damage. Cathodic protection is being considered as a protective means to reduce costs.

In Belgium a 70,000-volt power cable 16 kilometers long has been protected from corrosion failure since 1938 by cathodic protection.

J. Ferdinand Kayser, Gillette Industries, Inc. said cathodic protection was applicable to parts of prime movers, chemical plants, fine instruments and the like. A safety razor holder made of aluminum protected the edge of a razor blade from visible corrosion, but such protection tended to alter the physical characteristics of the metal in the vicinity of the edge. If the current protecting the edge were increased unduly the edge would wear away at a rate roughly proportional to the current density.

Corrosion of Buried Copper and Ferrous Strip in Natural and Salted Soils by the British Electrical and Allied Industries Research Association and **Tests on the Corrosion of Buried Aluminum, Copper and Lead** by P. T. Gilbert and F. C. Porter. Investigations to determine relative corrodibility of various soils on metals used for earth electrodes have been conducted over 12 years. Cast iron, Armco iron, mild steel, galvanized mild steel, copper and tinned copper were investigated in 12 soils salted and unsalted.

(Continued on Page 17)

British Estimate—

(Continued from Page 16)

Tinned copper was most corrosion resistant, losing 0.1 percent per year by weight compared to nearly 2 percent for ferrous specimens. Galvanizing gave protection for 12 years. Salting increased corrosivity.

Tests on commercially pure aluminum, phosphorus deoxidized arsenical copper and lead buried at the same time at the same sites as ferrous specimens in the preceding papers were conducted. Aluminum was severely pitted in all soils after 5 years except moist neutral clay. Cinders caused severe attack on copper and lead was attacked in one soil and moderately attacked in four.

Discussion. The use of puddled clay for aluminum pipe protected with a bitumen/barium type coating was suggested as a suitable method to be investigated. Of 130,000 miles of buried cable belonging to the British Electrical Authority most had some kinds of protection. The standard was two bitumized paper tapes, two bitumized cotton tapes and one bitumized hessian tape. These coverings were effective against chemical attack but not so effective against stray currents to combat which armoring was found to be necessary between the cotton and the hessian. There were 106 corrosion faults in 1949-50 or 0.08 per year per 100 miles. Of these 63 resulted from electrolytic attack; 27 were due to chemical attack of which five were attributed to local contamination and the remainder to aggressive soil. Causes of 16 corrosion failures were unknown.

Lack of pitting data in the copper strip tests was deplored and the general usefulness of the tests was questioned.

R. L. Davies, British Insulated Callenders Cables, Ltd., said aluminum might not be trustworthy under anerobic conditions. Further investigation of copper contamination in the electrolyte when aluminum corroded is planned.

AIChE Corrosion Session Scheduled

Akron, Ohio sections of the American Institute of Chemical Engineers are presenting a symposium on corrosion at Akron April 21. Many speakers on the program are members of the National Association of Corrosion Engineers, according to Ralph A. Troupe, Goodyear Synthetic Rubber Corp., publicity chairman.

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The American Institute of Chemical Engineers will have a meeting March 16-19 at Atlanta, Ga. with headquarters at the Biltmore Hotel. Twenty-five technical papers will be presented.

Lubrication Engineers

Technical and semi-technical phases of scientific lubrication and their practical application will be discussed in 33 papers and at three question and answer sessions of the American Society of Lubrication Engineers' 1952 Annual Meeting. The gathering will be held April 7-9 at Hotel Statler, Cleveland.

119-1

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International Nickel Co. of Canada is pumping approximately 1800 tons of nickel-copper concentrate and 8200 tons of tailings daily through a 7½ mile wooden pipeline from its Creighton concentrator to its newly built reduction plants at Copper Cliff, Ontario. Three million board feet of lumber and 40 miles of wooden pipe were used. The system is designed to be self-draining in case of a power failure.

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Ferr-O-Niel 985, an acid surface conditioner manufactured by the Nielco Laboratories, Box 4703, Detroit 19, Mich. is described in a Technical Data Sheet. It is described as a carefully balanced, non-corrosive acid surface conditioner built from a phosphoric acid base and designed to remove light oil, soil, normal oxides and smut without changing tolerances or building hydrogen embrittlement. It is recommended for use on ferrous metal parts such as stampings, machined steel parts, shaftings, pistons, valves, tappets and castings, including Meehanite prior to assembling, painting or plating. A method is described where surface protection from corrosion is given by a hot water bath charged with Nielite Fix which gives a coating good for two weeks or more. Ferr-O-Niel is said to produce no corrosive fumes and is non-toxic.

•

Dow-Corning Corporation's traveling exhibit consisting of about 16,000 pounds of samples, parts, assemblies and machines which demonstrate the uses and properties of the silicones has scheduled the following appearances: March 17-28—Los Angeles Elks Club, Los Angeles, Cal.; April 9-11—Broadview Hotel, Wichita, Kans.; April 15-17—Texas Hotel, Fort Worth; April 22-24—Shamrock Hotel, Houston. The exhibit can be covered in about half an hour but two hours or more are required to fully digest all the information made available. Technical representatives of Dow Corning staff the exhibit.

•

Spang-Chalfant Division of National Supply Company, Pittsburgh, Pa. has issued a pocket sized booklet "How to Make Drill Pipe Last Longer" which explains briefly the results of fatigue and corrosion fatigue in drill pipe.

•

H. J. Heinz Company's new $15,000,000 Vinegar Building at Pittsburgh features concrete sub-floors, tiled walls in filling rooms and acid-resistant floors.

•

Philip Carey Manufacturing Co., Lockland, Cincinnati, Ohio will display Standard Windmaster Shingles, Double V-Lock, Asbestos Siding, Careystone roofing and siding and bathroom cabinets at the NACE Conference and Exhibit March 10-14 at Galveston.

•

Steelcote Manufacturing Co., Gratiot at Theresa, St. Louis 3, Mo. has developed a coating consisting of a water white plastic with 18-8 stainless steel Type 302 powdered as a pigment. High stability and excellent resistance to numerous organic and inorganic corrosives is claimed. A data sheet giving full information is available on request.

•

Tubular Products Division of Babcock & Wilcox Company is now making seamless stainless steel tubing by the Ugine-Sejournet extrusion process at its Beaver Falls, Pa. plant. It is believed to be the first United States plant to make tubing in this way. The distinguishing characteristic of the method is the use of glass as a lubricant for the hot worked metal and as an insulator to protect the die system. The first lot of tubing produced was B&W Croloy 18-8.

•

National Carbon Company, Union Carbide and Carbon Corp., 30 East 42nd St., New York 17, N.Y. has available for distribution Catalog Section S-6210 which lists the principal features of carbon, graphite and impervious graphite, some typical metallurgical and chemical applications, and includes tables of brick size, shapes and grades. Karbate brand impervious corrosion resistant carbon and graphite standard brick shapes and sizes are shown in con-

•

U. S. Stoneware Company, Akron, Ohio offers its Bulletin AB-17, "How to Build Corrosion Resistant Floors." The bulletin, consisting of 16 pages, describes acid brick, different types of cement, details of various kinds of floors and includes photographs of installations.

•

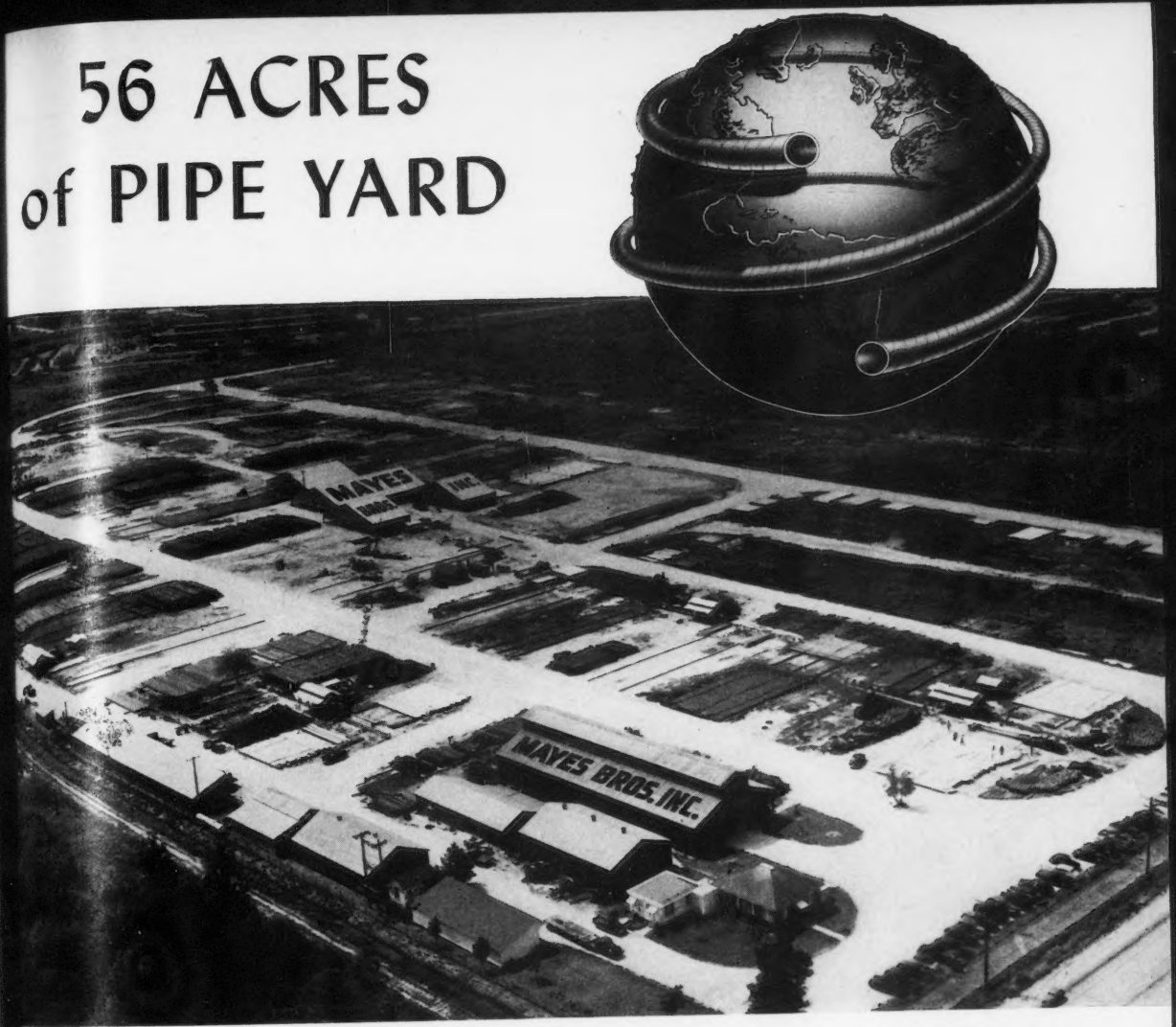
Tenite Pipe Installations in Tennessee Eastman Company Plant, a publication of Tennessee Eastman Company, Kingsport, Tenn. gives data on installations, temperatures, pressures, approximate flow and nature of material carried. The company claims the cost of extruded Tenite II clear pipe is considerably less than that for stainless steel pipe. Workmen, the report states, like the transparency because it permits observation of flow. Satisfactory service is claimed. Photographs show extrusion machines, coupling techniques, types of bends, and indoor and outdoor installations under various conditions.

•

Royston Laboratories, Inc., Blawnox, Pa. has introduced a special pipe wrapping fabric "Glas-Wrap" for reinforcing its Roskote cold-applied mastics against mechanical abrasion during handling and backfilling. It is especially designed for hand wrapping and is non-irritating to the skin. A copy of the firm's Glas-Wrap Bulletin is available on request.

Send in News For APRIL CORROSION to reach Houston Before March 10

56 ACRES of PIPE YARD



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HOUSTON

PERSONALS

Commander W. J. Copenhagen, government corrosion chemist, with the government of the Union of South Africa, P. O. Box 668, Capetown, S.A., a corresponding member of TP-6G on Surface Preparation is one of two men in the union engaged full time on corrosion problems. He is interested in the corrosion of metals. Mr. Copenhagen expressed an interest in meeting members of NACE who may visit South Africa. J. N. Wanklyn of the Council of Scientific and Industrial Research, Pretoria, is the other full-time corrosion worker.

A. B. Lauderbaugh has been promoted to the position of chief engineer of Manufacturers Light and Heat Co., Pittsburgh, Pa. He has been the company's chief gas engineer since 1947. His new duties include responsibility for corrosion. A native of Oswego, N.Y. he is a graduate of Bucknell University and has been connected with gas companies since 1928.

•

Richard South has joined Atlas Mineral Products Co. sales department with an assignment to Southern Ohio, West Virginia and Kentucky.

•

E. L. "Jack" Henry, has been put in charge of the newly formed Stationary Pipe Coating and Wrapping Division of Crutcher-Rolfs-Cummings, Houston.

Mr. Henry has worked both as a supervisor and as inspector in all phases of the pipe line business. He was formerly with Barrett Division, and Trunkline Gas Company.

•

Dr. George O. Curme, Jr., vice-president in charge of research activities of Union Carbide and Carbon Corporation, has been elected a director of the firm.

•

Carleton B. Edwards has been elected president of Reilly Tar and Chemical Corp. and Republic Creosoting Company, succeeding the late **Peter C. Reilly.** He is a graduate of Earlham College and past president of the board of trustees of the Town of Meridian Hills. Thirty-one years with the Reilly companies, he has been research chemist, director of research, production manager and for the last 10 years, general manager.

•

Lincoln D. Hall has been appointed Mid-Continent District manager by Tube Turns, Inc., Louisville, Ky. He formerly was West Coast Sales manager for Taylor Forge & Pipe Works and has had extensive experience in industrial piping.

•

F. L. Goldsby, an employe of Chicago Bridge and Iron Company for more than 20 years, has been named to succeed **W. D. Robinson** in the company's export department in New York City. Mr. Robinson retired December 31. A native of Illinois, Mr. Goldsby has a bachelor of science degree from University of Illinois, 1927.

•

E. M. Converse, Senior Vice-President of Dearborn Chemical Company has retired after almost a half century of service.

•

Lester B. Swan, general manager of United Oilwell Service, S.A., Caracas, Venezuela has been named assistant manager of Dowell Incorporated in Tulsa. **Tromer Smith,** formerly Eastern Division manager of United, an associate company of Dowell, has been named to succeed Mr. Swan **Basil Hodges,** formerly with Dowell at El Reno, Okla. will replace Smith as Eastern Division manager for United. Swan formerly was district manager for Dowell at New Orleans and previous to that was a development engineer at Tulsa.

•

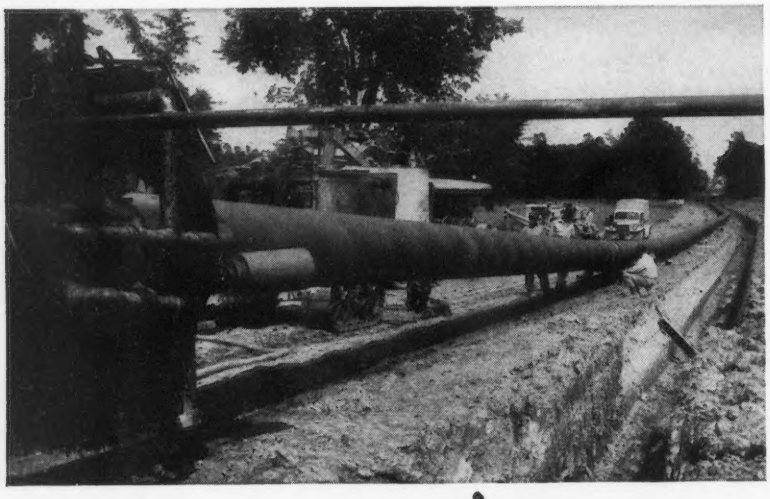
Melvin W. Pauly has been named Eastern Division sales manager, **Harold H. Layritz,** Central Division sales manager and **Charles W. Burrage,** Western Division sales manager in a general reorganization of the Lunkenheimer Company's sales organization effective Jan. 1.

•

A. P. Richards has been elected president and made director of the William F. Clapp Laboratories, Inc. Duxbury, Mass. succeeding the late Dr. **Wm. F. Clapp.** The laboratories are devoted to the study of marine organisms throughout the world, bacteria and fungi, salt water corrosion and protective coatings and the control of fouling by marine organisms.

•

Alfred L. Lee, Edward R. Bergin and **Alfred Blackstone** have been added to the sales staff of Federated Metals Division of American Smelting & Refining Co.



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Over 300 more miles of the Tennessee Gas Transmission Company's Buffalo Extension gas line have recently been covered with Ruberoid Imperial Asbestos Felt. Delivering 200,000,000 cubic feet of gas per day, this new 24" line will perform a much needed service for the people and industries of western New York, and Ruberoid is proud to have contributed to its completion. The pipe line engineers and contractors on this job—as on many others — know that Ruberoid pipe line felt, in conjunction with a proper enamel coating, provides the best defense against both physical and corrosion hazards.

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Corrosion Abstracts

CORROSION CONTROL — PROTECTS INDUSTRY — NATIONAL ASSOCIATION OF CORROSION ENGINEERS

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(Breakdown of Industry groups will be found in Index to Technical Material, Corrosion, December, 1951)

5. PREVENTIVE MEASURES

5.4 Non-Metalilc Coatings and Paints

5.4.5, 6.4.2

New Vinyl Finish for Aluminium Alloys. *Modern Metals*, **6**, No. 12, 44 (1951) Jan.

T. I. Aluminum Ltd., Birmingham, has developed a new vinyl enamel for aluminum which is claimed to have a wide range of advantages. Called Tightamel, the finish requires relatively short baking periods of only 3 to 5 minutes at 250°F. (121°C.). The enamel adheres well to all aluminum alloys and will withstand bends as severe as 180 degrees. The enamel is extremely waterproof and does not absorb water and fade. Excellent resistance to a wide selection of corrosive compounds is claimed. However, the enamels possess rather poor resistance to heat and continued exposure to temperatures above 210°F. (98°C.) causes discoloration and eventual reduction of adhesive strength. Tightamel is non-toxic and odorless which makes it suitable for food containers. Seven colors are now available and others will be introduced. The enamel can be applied by spraying, dipping, or roller coating and can be air dried although baking is preferred. The only pretreatment required is degreasing and one gallon of the enamel will cover 50 to 70 sq. yds. of surface.—ALL.

5.4.5, 8.5.3

Protective Coatings Prevent Pulp Mill Corrosion. R. H. Maloy. Insul-Mastic Corp. Am. *Paper Trade J.*, **131**, No. 25, 18+ (1950) Dec. 21.

Discussion of the development, qualities and uses of coatings manufactured by the author's company shows the ways in which protective coatings serve the paper and pulp mills. Particular attention is paid to Insul-Mastic, a mastic type coating, compounded around the bitumen, Gilsonite. It contains mica filler, and asbestos fiber and ceramic clay for spraying smoothness and additional durability.—INCO.

5.4.5, 5.4.7

Technology and Application of Aluminum Paint. A. S. Khanna. *J. Inst. Chem.*, (India), **22**, Pt. 3, 117-126 (1950).

Aluminum paints have been developed only in the last 25 years, although used for special purposes much earlier. The longevity and resistance of these paints to weathering relies upon leafing properties of the metal flakes in the vehicle, which must have a sufficiently high yield value and plasticity to avoid runs, sags and breaks. Synthetic resins such as phenolic and alkyd types are satisfactory, but natural and modified natural resin varnishes may be used. Aromatic hydrocarbons such as xylol or high-

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CODE OF AGENCIES SUPPLYING CORROSION ABSTRACTS

AER—Aeronautical Engineering Review, Institute of Aeronautical Sciences, Inc. 2 East 64th St., New York 21, N. Y.

ALL—The Abstract Bulletin, Aluminum Laboratories, Ltd. P. O. Box 84, Kingston, Onatrio, Canada.

AWWA—Journal, American Water Works Association. Amer. Water Works Assoc., 521 Fifth Ave., New York 17, N. Y.

BL—Current Technical Literature, Bell Telephone Laboratories, Inc., Murray Hill, N. J.

BLR—Battelle Library Review, Battelle Memorial Institute Library. 505 King Ave., Columbus, Ohio.

BNF—Bulletin; British Non-Ferrous Metals Research Association. 81-91 Euston St., London NW 1, England.

CALCO—Calco Chemical Division, American Cyanamid Corp. Bound Brook, New Jersey.

CE—Chemical Engineering, McGraw Hill Publishing Co. 330 W. 42nd St., New York 18, N. Y.

CEC—Consolidated Edison Co. of New York, Inc. 4 Irving Place, New York 3, New York.

EL—Electroplating. 83/85 Udney Park Road, Teddington, Middlesex, England.

EW—Electrical World, McGraw-Hill Publishing Co. 330 W. 42nd St., New York 18, N. Y.

GPC—General Petroleum Corp. of California. 2525 East 37th St., Los Angeles 11, Calif.

INCO—The International Nickel Co., Inc. 67 Wall Street, New York 5, New York.

IP—Institute of Petroleum, 26 Portland Place, London W#1, England.

MA—Metallurgical Abstracts, Institute of Metals, London, England. 4 Grosvenor Gardens, London SW 1, England.

MI—Metallurgia Italiana. Associazone Italiana di Metallurgia. Via S. Paola, 10, Milano, Italia.

MR—Metals Review, American Society of Metals. 7301 Euclid Ave., Cleveland 3, Ohio.

NALCO—National Aluminate Corp. 6216 West 66th Place, Chicago 38, Illinois.

NBS—National Bureau of Standards. Supt. of Documents, U. S. Gov't Printing Office, Washington 25, D. C.

NSA—Nuclear Science Abstracts. United States Atomic Energy Commission, Technical Information Division, Oak Ridge, Tenn.

PDA—Prevention Deterioration Abstracts. National Research Council, 2101 Constitution Ave., Washington 25, D. C.

RA—Refrigeration Abstracts, American Society of Refrigeration Engineers. 40 West 40th St., New York 18, N. Y.

RM—Revue de Metallurgie, Paris, France. 5 Cite Pigalle, Paris (9e), France.

RPI—Review of Current Literature Relating to the Paint, Colour, Varnish and Allied Industries, Research Association of British Paint, Colour & Varnish Manufacturers, London. Waldegrave Rd., Teddington, Middlesex.

TDD—Technical Data Digest, Air Material Command—Technical Service Section, Central Air Documents Office, Wright-Patterson Air Force Base, Dayton, Ohio.

TIME—Transactions of Institute of Marine Engineers. 85 The Minories, London EC 3, England.

UOP—Universal Oil Products. 310 South Michigan Ave., Chicago, Illinois.

ZDA—Zinc Development Association. Lincoln House, Turl Street, Oxford, England.

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1F	Yes	Yes	Primer	3/32" Enamel	Asbestos Felt	Kraft				Yes
1G	Yes	Yes	Primer	3/32" Enamel	Glass	Kraft				Yes
1XF	Yes	Yes	Primer	3/32" Enamel	Asbestos Felt	2/32" Enamel	Kraft			Yes
1XG	Yes	Yes	Primer	3/32" Enamel	Glass	2/32" Enamel	Kraft			Yes
2F	Yes	Yes	Primer	3/32" Enamel	Asbestos Felt	2/32" Enamel	Asbestos Felt	Kraft		Yes
2G	Yes	Yes	Primer	3/32" Enamel	Glass	2/32" Enamel	Glass	Kraft		Yes
2GF	Yes	Yes	Primer	3/32" Enamel	Glass	2/32" Enamel	Asbestos Felt	Kraft		Yes
2XF	Yes	Yes	Primer	3/32" Enamel	Asbestos Felt	2/32" Enamel	Asbestos Felt	2/32" Enamel	Kraft	Yes
2XG	Yes	Yes	Primer	3/32" Enamel	Glass	2/32" Enamel	Glass	2/32" Enamel	Kraft	Yes
2XGF	Yes	Yes	Primer	3/32" Enamel	Glass	2/32" Enamel	Asbestos Felt	2/32" Enamel	Kraft	Yes

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flash naphtha also help the leafing. Properly formulated films show good resistance to water and corrosive fumes, and good hiding power. Aluminum paints are generally poor conductors, but at voltages between 100 to 300 v. the film may become conducting. For application to wood, brick, and interior structural steel the paint needs no primer, but for exterior steelwork a rust-inhibiting primer is recommended. All modern methods of application are suitable such as brushing, spraying, dip, flow and roller coating. Fire risk can arise if the paint is struck with metal, when sparks may be produced, but the conditions to produce this hazard are exceptional.—RPI.

5.4.5, 2.3.5, 3.5.5

Effect of Pigment Materials on the Protective Properties of Paints Against Corrosion. C. KALAUCH. *Werkstoffe u. Korr.*, **1**, No. 10, 400-404 (1950).

The electrochemical concept of metallic corrosion is discussed with special references to the ability of certain basic pigment materials to influence the cation and anion permeabilities of paint film. The inhibiting merits of various basic inorganic and organic pigment materials (e.g., red lead, zinc oxide, amino-resins, etc.), present in polyvinyl chloride films were investigated by electro-dialysis and by current-time curves. The interpretation of the measurements is briefly discussed from the point of view of ion permeability and adsorption.—RPI.

5.4.5

The Role of the Vehicle in Paints for Submerged Surfaces. A. C. ELM. Paper, 3rd Ann. Paint Colloq. New York Nov. 18, 1950. *Paint, Oil Chem. Rev.*, **114**, No. 5, 13-14+ (1951) Mar. 1.

The mechanism by which the vehicle of a paint used on underwater structures acts as a moisture barrier and thus prevents corrosion is discussed.

5.4.5, 7.2, 4.6.1

Performance of Coal-Tar Enamel on Steel Water Pipe and Penstocks. G. E. BURNETT. *J. Am. Water Works Assoc.*, **42**, 741-748 (1950).

Coal-tar enamel is effective in controlling internal corrosion of steel water pipe.—RPI.

5.4.5

Prevention From Corrosion Through New Lacquer Methods. E. GLUCKLICH. *Ind.-Lack.-Betrieb*, **1942**, No. 25, 26, 170-172.

The choice of materials and methods for anti-corrosive lacquering is discussed in relation to the mechanical and chemical requirements of the coatings. Polishing N. C. lacquer films increases their corrosion resistance as the remaining pores in the films are filled.—RPI.

5.4.5

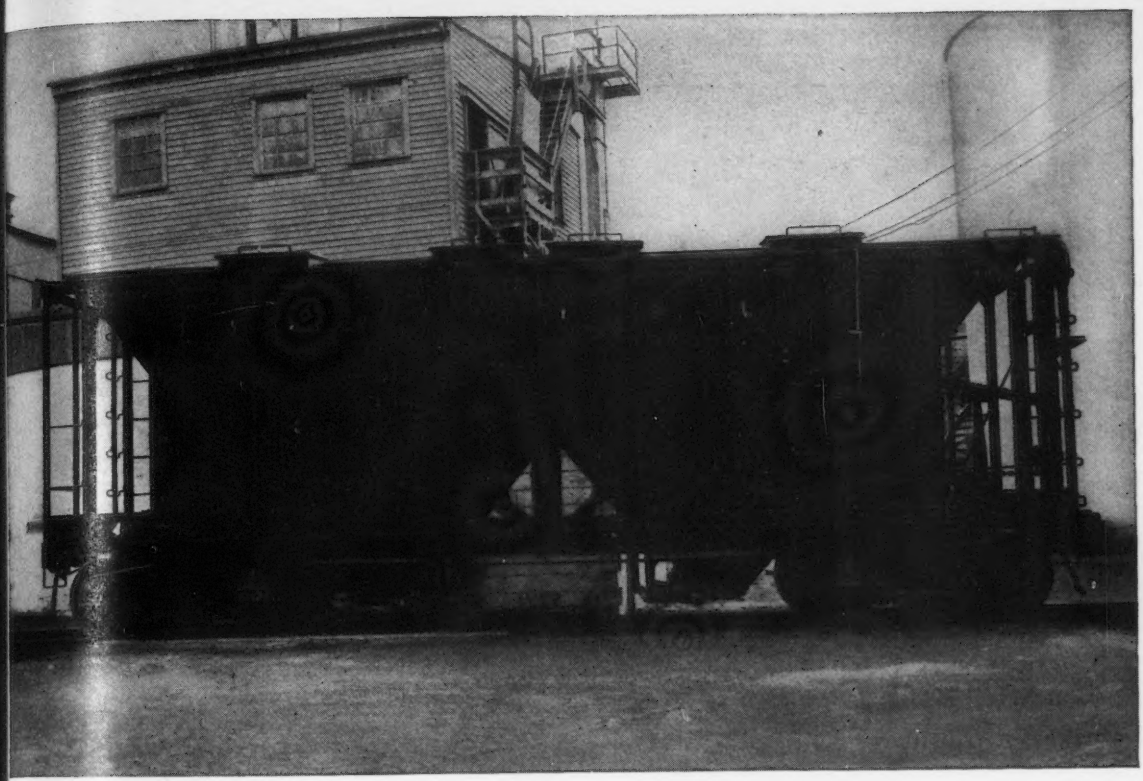
Anti-Corrosive Pigments. *Chem. Age*, **63**, 772 (1950) Dec. 2.

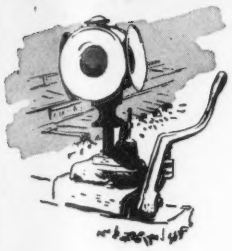
Briefly outlines recent German, British and U. S. work on pigments consisting of inert particles coated with anti-corrosive coloring agents.—BLR

5.4.5.

Remarks on the Properties of Anti-corrosive Pigments and Their Vehicles. M. RAGG. *Paint, Oil Chem. Rev.*, **114**, No. 8, 16-17 (1951) Apr. 12.

It would not be considered good prac-





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For fifteen months, this hopper car has been hauling corrosive soda ash —a substance that makes a steady diet of car coatings.

The stenciling, done with ordinary enamel, disappeared long ago. But the paint covering the car is still there with *months* of service ahead. Beating the car with hammers to loosen the load broke the surface in spots. But the coating stuck firm around them, preventing rust creepage.

That's how properly formulated, properly applied coating systems based on VINYLITE Brand Resins stand up. On metal, concrete or masonry, they resist oil, water, corrosive atmospheres, and most chemicals. Dry in a few minutes, they're odorless, tasteless, non-toxic and non-flammable.

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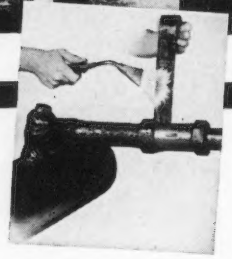

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tice today to try to protect an iron structure with a clear varnish. This purpose can be attained much more easily and better simply by incorporating a suitable pigment in the vehicle or binder. This increases the mechanical and possibly the chemical resistance of the coating—and is especially helpful in reducing the swelling of the coating in the presence of moisture. In short, protection can be best obtained by painting the structure with an anticorrosive paint. The physical, chemical and electrochemical properties of anticorrosive pigments are discussed.—TDD.

5.4.5, 4.1

New Mica Base Paint System Withstands Severe Atmospheric Conditions. J. G. Ford and A. J. Kuti. Westinghouse Elec. Corp. *Materials & Methods*, **32**, No. 5, 58-61 (1950) Nov.; *Ind. Finishing*, **27**, No. 11, 38-54 (1950) Nov. *Org. Finishing*, **11**, No. 11, 7-11 (1950) Nov.

Coastal Finish, a 3-coat mica base paint system, was developed specifically for distribution transformers, but will undoubtedly find use on many other products that require high resistance to varying atmospheres. The prime coat is composed of a vehicle giving good adhesion with desired flexibility and chemical resistance to salts, acids and alkalies. The pigments used are primarily zinc chromate and zinc oxide. The vehicle of the second coat is composed of modified phenolic and alkyd resins. The pigment is composed of selected mica flakes which overlap each other in the film and produce a shingle roof effect to further ward off moisture and oxygen. The third and final coat is composed of resins and pigments to withstand the elements and to provide good appearance when new and after weathering has taken place. A total of 10,000 hr. continuous exposure to salt spray was required before small blisters began to appear on the mica finish. Results of tests on salt spray, acid and alkali and weathering resistances of Coastal Finish are given.—INCO.

5.4.5

Baker Synthetic Enamels Versus Porcelain Enamels. T. A. Dickinson. *Org. Finishing*, **11**, No. 5, 14-16 (1950).

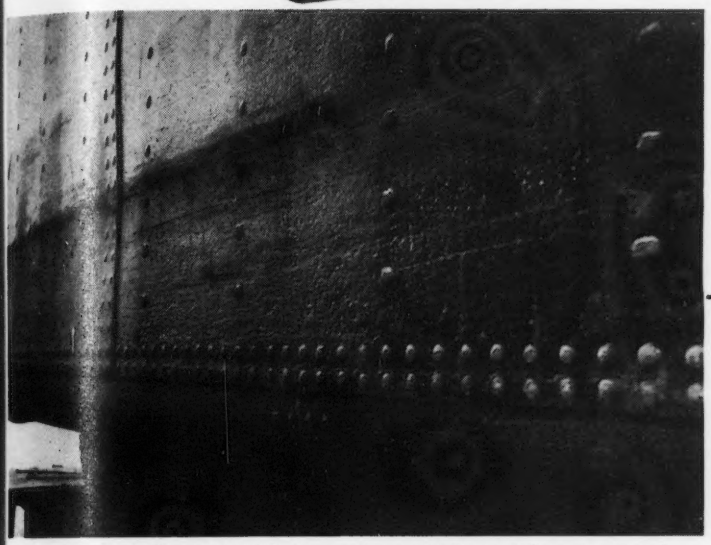
Baked synthetic enamels are more flexible than porcelain enamel; they more effectively prevent corrosion, because the high fusion temperature of porcelain tends to oxidize the base metal; have less heat resistance; have greater chemical resistance in some cases and have better adhesion.—RPI.

5.4.5

Two Years of Styrenated Alkyd Resins for Surface Coatings. William H. Patrick and Emory H. Trussell. *Official Digest, Federation Paint and Varnish Production*, **1950**, 767-778, Oct.

Typical white enamels were made by dispersing rutile TiO_2 in both "Rezyl" Resin 330-5 and "Cycopol" Resin S101-1 on a 3-roller mill. The reduced enamels were then sprayed on bright steel panels, air dried 20 min., and baked. The data clearly demonstrate the effects of the melamine-formaldehyde resins in shortening curing schedules and greatly improving chemical resistance. Exterior durability, lifting and solvent sensitivity and use in metal undercoats were studied.—BLR.

NO CORROSION



after 17 years in the Delaware River!

Photograph taken in July, 1950, shows coal barge, "Walling", which was zinc sprayed in 1933. Work done by Metalweld, Inc., Philadelphia, Pa. Note excellent condition of rivets and seams.

That's the service record of this steel barge. And it's still good for many more, even in these notoriously corrosive waters, thanks to the metallized zinc on its hull.

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5.4.5, 3.8.4

Corrosion Protection by Polar and Non-Polar Coatings. Part III. E. MANEGOLD. *Fette u. Seifen*, **52**, 725-728 (1950) Dec.

The mechanism of protection against chemical and electrochemical corrosion is discussed in terms of the previously presented theory of the dialysis potential.

5.4.7, 6.4.2

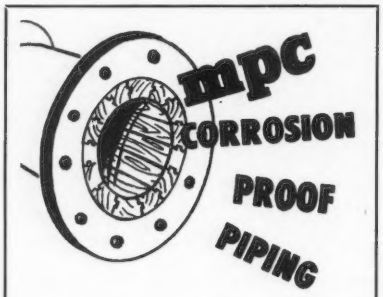
Ministry of Health — Recommendations for the Repainting of the Exterior Metalwork of Temporary and Permanent Aluminium Bungalows. *Decorator*, **49**, No. 581, 57-58 (1950).

Care must be exercised when preparing the surface for repainting to avoid damage to Alclad sheeting; bristle brushes must be used in place of wire brushes and no feathering down with abrasive paper is permissible. All corrosion products must be washed off. Recommended repainting comprises priming bare patches with ferric oxide/zinc chromate varnish-based primer followed by one or possibly two coats of rutile titanium dioxide/linseed oil paint. —RPI.

5.4.7, 8.3.4

Protection Against Corrosion in Breweries. H. NETZ. *Werkstoffe u. Korrosion*, **1**, No. 11, 444-446 (1950).

Painting is the most suitable protection against corrosion in breweries, but strong smelling and tasting compositions and poisonous pigments should be avoided. The best materials are varnish enamels, chlorinated rubber (especially in priming coats) and synthetic resins. The toughest and most adherent films are required for refrigerating plant where temperature fluctuations occur.—PRI.



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5.4.7

Improve Product Appearance With Electrolytic and Chemical Finishes. *Product Eng.*, **22**, 141-148 (1951) Feb.

Special section covers classes and types; how base metal affects selection; appearance and protective finishes; new developments and industry trends; and examples showing appearance of products by means of colored photographs. Also includes comprehensive folded chart which shows properties, limitations, specifications, surface preparation and uses of all types of organic, inorganic and specialty finishes for metals. —BLR.

5.4.7, 7.6.4

Graphite as Boiler Protection. W. LEX. *Die Technik*, **5**, No. 6, Appendix. *Fertigungstech.*, **3**, 35-36 (1950).

In order to delay boiler incrustation and facilitate its removal, crystalline graphite should be contained in the paint used for coating the inner surfaces. The carbon content of the crystalline graphite is about 87 percent and, as it is extremely finely ground, it can readily be added as a suspension in paints, which then give a film from which the scale can easily be removed by brushing.—RPI.

5.4.7

Practical Factors in Applying Organic Finishes. M. KRONSTEIN. N.Y.U. *Elect. Mfg.*, **46**, No. 5, 97-101+ (1950) Nov.

Selection and application of organic coatings other than insulating varnishes. Service life factor, definition of paint system, compatibility of coatings, drying and baking methods, classification of clear varnishes and lacquers, pitfalls in shop mixing, thickness and control tests, and variations in gloss and color are discussed. Inconel test panels are used for testing pigmented insulation coatings. A vinyl-butyral resin solution known as "Wash-Primer" is used as a primer coat.—INCO.

5.4.7, 8.4.3

Off-Shore Corrosion. *Paint Manuf.*, **20**, No. 12, 426 (1950) Dec.

A note describing anticorrosive coatings applied to off-shore drilling platforms in the Gulf of Mexico. Above high water mark, but below the floor of the platform, a special petroleum compound pigmented with zinc dust and zinc oxide is used. It is applied by a trowel or swab and is non-drying. On the super-structure alkyd vehicle paints pigmented with zinc chromate and red lead are used.—ZDA.

5.8 Inhibitors and Passivators

5.8.2, 4.4.2, 4.6.8

Two New Corrosion Inhibitors. *Hercules Chem.*, No. 20, 15 (1950) Dec.

Hercules Polyethanol Rosin Amine D-1100 and Polyethanol Rosin Amine D-0500 are announced by Hercules Powder Co. for use in hydrochloric acid and natural brines. They are viscous liquids obtained by reacting Hercules Rosin Amine D with ethylene oxide.

5.8.2, 4.3.2

Halides as Acid Pickling Inhibitors. K. F. Hagers. (Dept. of Army) and M.

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Rosenthal. (Univ. Eng. & Chem. Consultants). *Corrosion*, **6**, No. 10, 344-346 (1950) Oct.

A new group of inorganic inhibitors consists of halogens and halides. Investigations were conducted in order to observe the mechanism of retardation and acceleration of acid pickling by the addition of compounds to determine the effect of halogens and halides on the acid attack against ferrous metals. Inhibition of acid attack on base metal was found to increase with the increase of atomic weight of the halogen in the molecules. The rate of oxide removal on rusted ferrous metal surfaces was not noticeably affected regardless of the halide used. Iodine and iodides were found to be effective inhibitors in concentrations of 0.1 percent and over. Bromine and bromides were next in effectiveness and chlorine and chlorides were also inhibitors. But iron and fluorides were accelerators of acid attack on base metal. The theory of halide inhibition of iron dissolution may be in the formation of a passivating monomolecular film of the iron halide. Mild steel (SAE 1010) pieces were used as material for test specimens. Tests were made in pickling solutions of 1 and 5 normal sulfuric acid and 5 percent nitric acid, using varying concentrations of inhibitors and several different temperatures for a number of test durations. Tables of results and 3 references are given.—INCO.

5.8.3

An Electrochemical Mechanism of Corrosion Inhibition by Chromates, Nitrites and Other Oxidants. M. Pourbaix and P. van Rysseibergne. Univ. of Oregon. Paper before Gordon Research Conf. on Corr., New London, N. H., July 1949. *Corrosion*, **6**, No. 9, 313-315 (1950) Sept.

The paper constitutes a portion of a theoretical and experimental study of inhibitors based upon the polarographic method. It classifies corrosion inhibitors as surface conversion, adsorption and diffusion inhibitors. Examples and a brief analysis of the mechanism of each is given. The role of the inhibitor is defined in a discussion of corrosion of iron by a solution free of oxygen with inhibitor absent. Consideration is given to the corrosion reaction when a chromate or nitrite has been added. Minimum inhibitor concentration for protection is shown to be that which for a given oxygen concentration brings the potential of the metal to a value corresponding to its passivation value.The electro chemical described shows that, at inhibitor concentrations insufficient for protection, both the inhibitor and oxygen are consumed in reduction reactions.—INCO.

5.8.4

Hydrophobization of Metal Powders as a Way of Protecting Them from Corrosion. A. I. Levin and A. V. Pomosov. *Doklady Akademii Nauk SSSR*, **72**, No. 6, 1075-1078 (1950).

Drawbacks of known methods of protecting metal powders from corrosion; formation of liquid adsorbed moisture film on powder particles as cause of corrosion; prevention of such a film by producing a hydrophobic adsorption film of surface-active organic compounds of aliphatic and aromatic series, or other substances. Experimental procedure; powder studied: Electrolytic copper. Test data on water-repelling and stabilizing action of 15 different active agents upon copper powder; 50-70-fold increase in corrosion resistance. Effect of hydrophobizing treatment on screen analysis and bulk density (2 figures, 2 tables, 1450 words). Translation available from Henry Brutcher, Box 157, Altadena, Calif.

5.9 Surface Treatment

5.9.1

Surface Preparation Values and Sandblasting Economics. A. J. Liebman. *Corrosion*, **6**, No. 5, 151-157 (1950).

Service requirements and coating characteristics are the deciding factors in the selection of surface treatment whether by wire brushing, flame cleaning, chemical etching, shot, grit or sandblasting.—RPI.

5.9.1

Research From Abroad. An Analysis of Recent Russian Work and Patents in the Metal Finishing Field. *Electroplating and Metal Finishing*, **3**, 453-454 (1950) Aug.—BLR.

5.9.2, 5.3.4

A Simple Test for Checking the Cleanliness of a Metal Surface. J. Liger. *Galvano*, **162**, 9-10 (1950).

A short summary and discussion of the method described by Hogaboom, *Proc. Am Electroplaters' Soc.*, **35**, 215 (1948); *Met. Abs.*, **17**, 216 (1949-1950), for ascertaining whether an iron or steel surface has been satisfactorily cleaned for subsequent electroplating.—MA.

5.9.2

Acid Dips in Cleaning Cycles. A Round Table Discussion. I. Acid Dips for Low Carbon Steel. II. Acid Dips for High Carbon Steel. III. Acid Dips for Copper and Copper Base Alloys. IV. Acid Dips for Zinc Base Alloys. *Proc. Amer. Electroplaters' Soc.*, 36, 127-147 (1949) (TS670 Am35p).

Each part has an introduction by a different author.—BLR.

5.9.2

Some Good Things to Know About Metal Cleaning. Illus. booklet from Oakite Products of Canada Ltd., 65 Front Street East, Toronto, Canada. Sept. 1950. 44 pp.

This booklet includes notes on tank and machine cleaning methods, electrocleaning steel and non-ferrous metals including zinc alloy die castings, pickling, barrel cleaning and burnishing. It recommends that phosphate treatment of zinc surfaces prior to painting should be done in an agitated tank.—BLR.

6. MATERIALS OF CONSTRUCTION

6.2 Ferrous Metals and Alloys

6.2.4

The Effect of Nitrogen on Brittle Behavior of Mild Steels. G. H. Enzian and G. J. Salvaggio. *Welding J.*, 29, 537s-544s (1950) Nov.

Investigation showed that the effect of nitrogen may not be as pronounced as previously indicated. In steels with low manganese-carbon ratios little or no change in brittle behavior was found with nitrogen variations within the range normally obtained by various open-hearth practices. Steels with higher manganese-carbon ratios exhibited, in general, somewhat better properties but these were more susceptible to variation with change in nitrogen content. Observations are made concerning comparison of tests and criteria used to determine transition temperatures. A good correlation was found between ductility transition temperature and sensitivity to cold work.—BLR.

6.2.2

The Crystal Structure of Graphite in Cast Iron. W. S. Owen and B. G. Street, Univ. of Liverpool. *J. Iron Steel Inst.*, 167, No. 2, 113-116 (1951) Feb.

The crystal structures of 1) graphite

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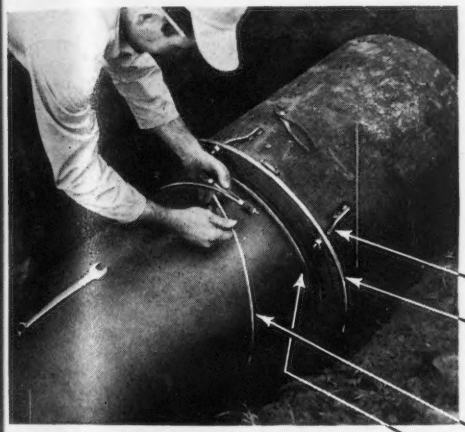

Assembling cable with rubber-covered union for clamping gasket lip to pipe.

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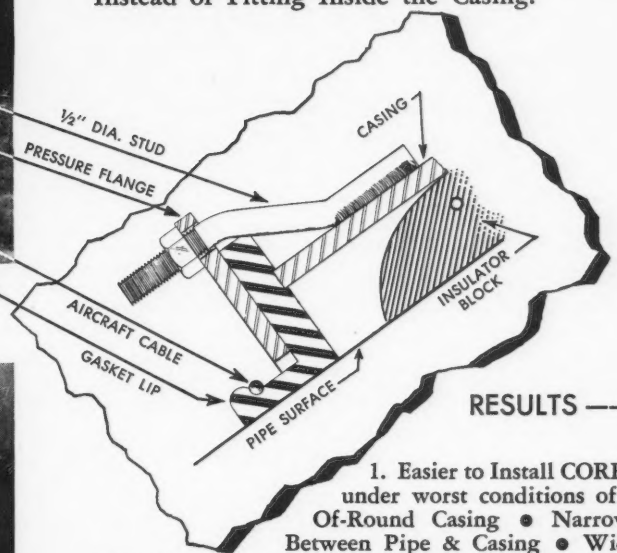

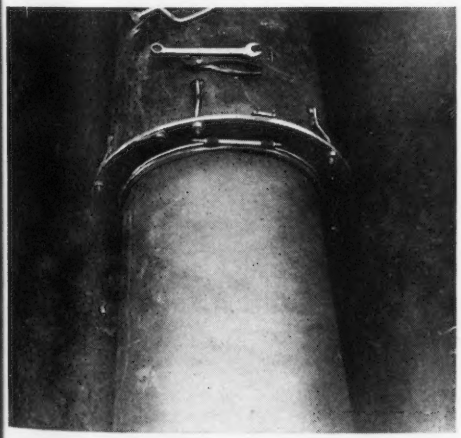

THE COMPLETED INSTALLATION
Note that galvanized cable and union are insulated from pressure flange and from pipe.

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2. WATER-TIGHT Seal with "L" gasket . . . . . .
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3. Always Insulated from the pipe line when a Concentric-Support Insulator is installed just inside casing after the "drag section" is in place.

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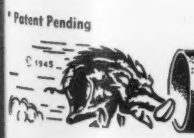

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extracted from an iron-carbon-silicon alloy prepared from high-purity materials, and 2) graphites from a variety of commercial cast irons, have been studied by the X-ray powder method. In all cases the structure was a mixture of the α and β structures found in other graphites of different origin. The proportions of α and β structures present vary considerably in the different forms of graphite and a correlation between the microscopic appearance and the crystal structure has been established. The parameters of the unit cells have been measured and as no variation from the accepted value for pure graphite has been found, it is concluded that the graphite occurring in iron-carbon-solicon alloys and in commercial cast irons is appreciably pure carbon.—TDD.

6.2.5, 1.3

Stainless Steels and Other Ferrous Alloys. W. B. DeLong and P. H. Permar. E. I. du Pont de Nemours & Co., Inc. Chem. Eng'g. Materials of Construction. *Ind. and Eng. Chem.*, **42**, No. 10, 2009-2019 (1950) Oct.

The literature on the stainless steels, their properties, corrosion resistance and methods of fabrication are reviewed. Significant progress has been achieved in the development of fundamental information on the structure and surface characteristics of these materials. Attention is given to their behavior in corrosive environments with particular emphasis on the significance of evaluation tests for the determination of the susceptibility of these alloys to intergranular attack. The extra-low-carbon alloys (0.03 carbon maximum) have assumed a position of real importance because they offer a means of meeting the need for sensitization-resistant material in the face of a possible shortage of niobium. The material included was published during the last half of 1949 and early 1950.—INCO.

6.2.5

Development of Chromium-Manganese Stainless Steels Using High-Purity Electrolytic Manganese for Alloying. D. N. Dhanbhoora and J. S. Vatchagandhy. *Trans. Indian Inst. Metals*, **3**, 309-331 (1949).

Effect of replacing wholly or in part the nickel in 18-8 chromium-nickel austentic stainless steel by high-purity manganese was investigated. A series of alloys with varying carbon, nickel and manganese contents were prepared and forged into bars. A study was made of the microstructures of these alloys and the results correlated with knowledge gained from a study of phase diagrams of the ternary iron-chromium-manganese system. Corrosion resistance of the alloys to atmospheric conditions, salt spray, nitric acid, sulfuric acid, intergranular attack and high-temperature oxidation was determined and compared with that of a standard 18-8 stainless steel. Physical properties of the alloys were also determined. Concludes that low-carbon 18 percent chromium steels containing 4-12 percent manganese and 0-4 percent nickel have considerable promise.—BLR.

6.2.5, 4.2.3, 4.3.5

Corrosion. Metals and Alloys Containing Vanadium or Exposed to Vanadium Oxide Are Subject to Rapid Oxidation.

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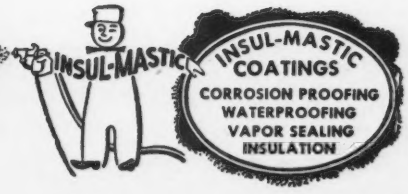

M. G. Fontana. *Ind. and Eng. Chem.*, **42**, 65-66A (1950) Oct.

Vanadium oxide produced from the combustion of vanadium-containing fuel oils, e.g. those from Venezuelan crudes can cause accelerated or "catastrophic" oxidation of metals. This particularly affects alloy steels containing vanadium, chromium, molybdenum, or tungsten, but also affects boiler tubes. An experimental study of the corrosivity of vanadium oxide, as contained in combustion gases and in the molten state, to various carbon and alloy steels is reported.

6.2.5, 3.7.2, 3.2.2

Corrosion. Mars G. Fontana. *Ind. and Eng. Chem.*, **42**, 99A-100A (1950) Nov.

Describes and illustrates case in which niobium failed to stabilize Type 347 stainless steel. Knife-line intergranular attack occurred immediately adjacent to the welds. Outlines tentative mechanism proposed to explain the situation, based on the effect of temperature on the solid solubility of columbium (niobium) in 18-8 stainless.—BLR.

6.2.5, 8.4.3, 3.5.9

Metallurgy for High-Temperature—Higher-Sulphur Process Conditions. F.N. Fahrenwald. *Petroleum Engr.*, **22**, No. 9, C11-C14, C16 (1950).

Stainless and other highly alloyed steels are mainly considered but reference is also made to nickel-chromium-iron alloys which are predominantly non-ferrous.—MA.

6.2.5

The Development of Stainless Wrought Steels. (Entwicklung und Stand der nichtrostenden Walz und Schmiedestaehle). K. Bungardt. *Stahl u Eisen*, **70**, No. 14, 582-596 (1950) July.

The characteristic feature of all stainless steels is the presence of a minimum of 12 percent chromium in their constituents. The addition of other constituents depends on the intended field of application. Austenitic chromium-nickel steels prevail over other steel alloys in malleable usage, with 18 percent chromium and 8 percent nickel representing the most popular, but not always the best-suited alloy types. Substitute nickel-poor steels developed in Germany during the war, notably those containing manganese, found widespread application in fields where good corrosion resistance was not of prime importance. Comparison between German production practices and those of other nations reveals little fundamental difference.—TDD.

6.2.5

Conference on Stainless Steels. (In Russian.) *Vestnik Akademii Nauk SSSR* (News of the Academy of Sciences of the USSR), **1950**, 66-71, Aug.

Briefly reviews 16 reports presented at above conference. Among the topics discussed were nature of corrosion resistance, intercrystalline corrosion, stress corrosion, corrosion by dilute sulfuric acid, manufacture of stainless steel, chromizing of iron and steel, diffusion coating with stainless steel, deep drawing of stainless steel and electropolishing and etching of stainless steel.—BLR.

6.3 Non-Ferrous Metals and Alloys—Heavy

6.3.2, 3.7.2

The Oxidation of Cadmium and Cadmium-Alloy Melts. (In German.) W. Gruhl and G. Wassermann. *Z. Metallkunde*, **41**, 178-184 (1950) June.

Above was experimentally studied. It was found that the oxidation of calm cadmium melts is a pure diffusion process. The oxide formed is not cadmium oxide but an unknown oxide phase. Lead, bismuth and copper up to 1 percent do not affect the oxidation of cadmium. 0.05 percent zinc suppresses the oxidation completely, while it is greatly increased by small additions of magnesium, tin and antimony, forming a spongy oxide.—BLR.

6.3.6, 1.3, 3.2.3, 3.4.6, 2.3.9

Review of Published Information on the Oxidation and Scaling of Copper and Copper-Base Alloys R. F. Tylecote. *J. Inst. Metals*, **78**, No. 3, 259-300 (1950-1951.)

Part I of the review describes methods used in experimental work on the oxidation of metals, including weighing, optical and electrolytic methods for measurement of oxidation rates, and X-ray and electron-diffraction methods for the study of oxide-film structures. The rate of oxidation of copper and the structure of the films formed are considered in Part II. There is a reasonably good agreement on the oxidation rate/temp. characteristic for copper, the logarithm of oxidation rate/reciprocal of absolute temp. curve consisting of two straight lines of different slopes intersecting at~600° C. In Part III are reviewed the influence of alloying elements on the oxidation of copper and some effects of variations in the oxidizing atmosphere. A comprehensive table incorporates references to all the work found dealing with the oxidation of copper-base alloys. Selective oxidation and subscale formation is included in this section and modern theories on oxidation phenomena are also discussed. Part IV deals with the practical aspects of oxidation, with particular reference to troublesome scales. Little has been published about the scaling characteristics of copper and copper-base alloys at normal processing temp. and slight information is available on the effects of impurities in bright-annealing atmospheres.—MA.

6.3.9, 6.3.15, 6.3.20

New Structural Metals. J. J. Harwood. Office of Naval Res. *Product Eng.*, **21**, No. 10, 96-102 (1950) Oct.

Properties, processing and fabrication, alloys and applications of titanium, physical and mechanical properties, fabrication, chemical and corrosion properties and alloys of zirconium, and physical properties, corrosion and oxidation and alloys of molybdenum are discussed. Titanium has a high corrosion resistance in marine environment, corrosion fatigue tests proving it superior to K Monel and 16 chromium-2 nickel steel. Unlike stainless steel titanium can be anodized. It has a weight advantage over stainless steel which is important in aircraft applications. Zirconium has a better corrosion resistance to alkalies than tantalum, titanium or 18-8 stainless steel. Alloyed with nickel, the yield strength doubles. Above 1000° C, the creep strength of molybdenum is superior to iron, nickel and cobalt base high temperatures alloys. Graphs, property tables and 9 references are given.—INCO.

6.3.15, 3.5.9, 7.1

High Temperature Alloys Based on Titanium Carbide. E. M. Trent and J. Bateman. *Metallurgia*, **42**, No. 250, 111-115 (1950) Aug.—MI.

6.3.15

They're Putting the Saddle on Titanium! *Steel Horizons*, **12**, No. 4, 3-5 (1950) Fall.

Some of the applications of titanium, dubbed the modern "wonder metal" by some quarters are discussed along with the inherent production problems encountered in bringing this metal into its own. For many years titanium oxides have been used in paints, face powder,

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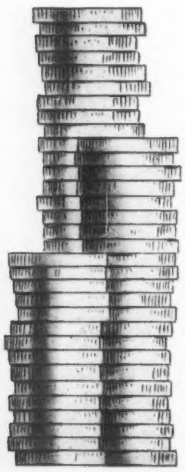

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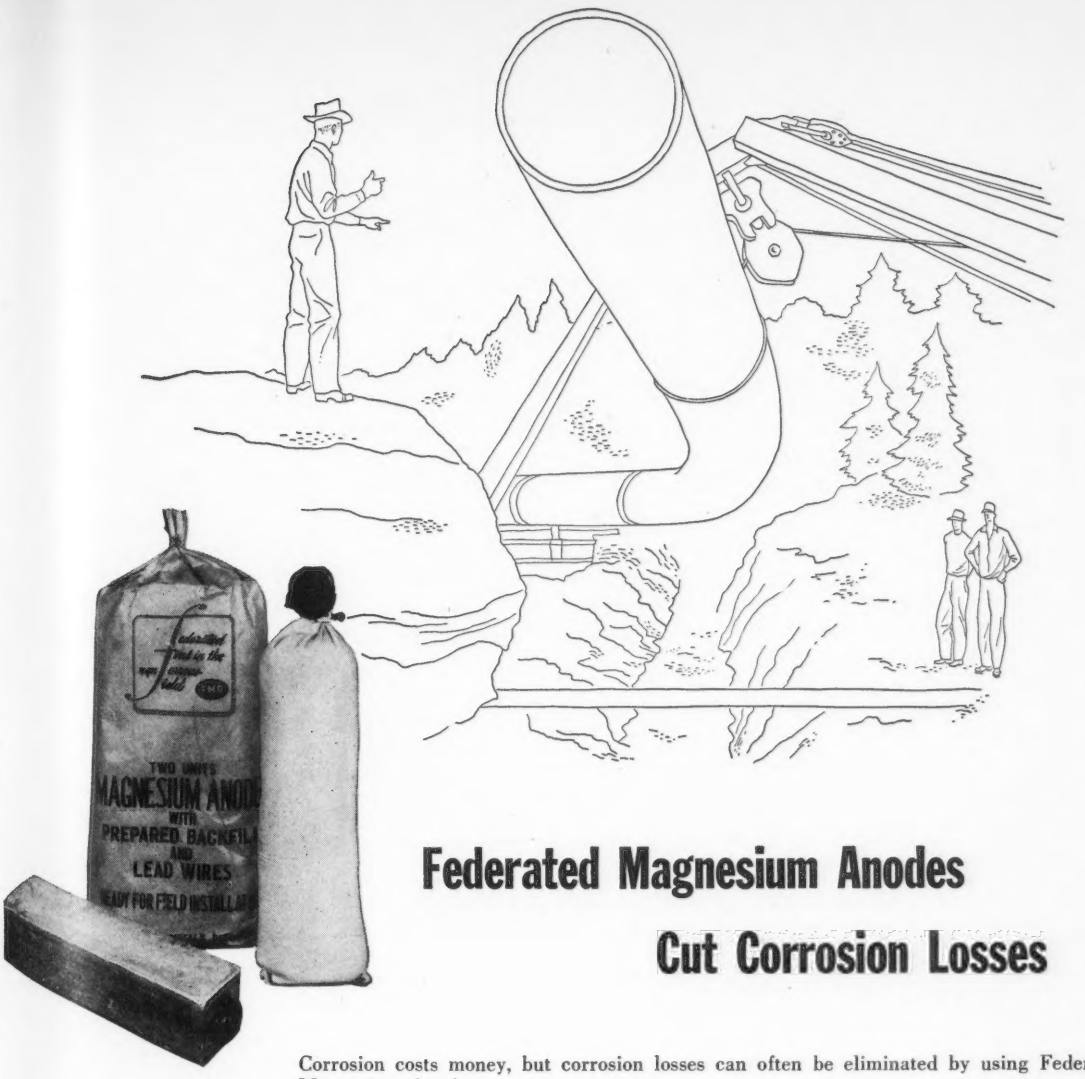

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glass-making, textile printing and plastices. But only since World War II have the nation's metallurgists found commercially practical ways of reducing titanium ore to metal—and even these methods must be improved to make the metal cheap enough for widespread use. Some of its interesting properties are that it is heavier than aluminum but lighter than stainless steel. Its known alloys are several times stronger than aluminum and rival the best steel alloys.—TDD.

6.3.21, 3.5.9

The High Temperature Oxidation of Manganese. R. S. Gurnick and W. M. Baldwin, Jr. *Trans. Am. Soc. Metals,* **42,** 308-318 (1950).—MI.

6.3.10, 4.6.11, 8.4.3, 2.2.7

The Behavior of Iron Modified 70-30 Cupro-Nickel Alloy in Salt Water and in Some Petroleum-Industry Environments. F. L. LaQue and J. F. Mason, Jr. International Nickel Co. Paper before Am. Petroleum Inst., Div of Refining, 15th Mid-Year, Cleveland, May 2, 1950. Am. Petroleum Inst., 1950, Reprint, 17 pp. In Reprint File). *Proc. Am. Petroleum Inst.,* **30M,** No. 3, 103-119 (1950).

A summary of data secured over the past several years in tests in salt water at Kure Beach and elsewhere to show the influence of the iron content of the 70-30 copper-nickel alloy on its resistance to corrosion and erosion. The conditions of exposure represented include long-time immersion in relatively quiet sea water; exposure to impingement attack by sea-water jets, with and without air bubbles; exposure to the erosive effects of sea water on specimens rotated through the water at high velocities; and tests in some polluted brackish water as encountered in condensers and heat exchangers. In addition, some information is provided on the effects of iron content on the development of protective films and the changes in potential of the alloy associated with the formation of such films. There is also appended some data on the rates of corrosion of the 70-30 alloy in various corrosive environments encountered in oil refineries —INCO.

6.3.15, 3.5.9

Preparation and Properties of Titanium-Chromium Binary Alloys. D. J. McPherson and M. G. Fontana. Am. Soc. Metals, Preprint No. 40, 1950, 28 pages. (TS300 Am35t.)

Describes 2 furnaces developed for investigation of the above by induction and arc melting. Chemical, spectrographic, and vacuum-fusion analyses, hardness and hot hardness, room-temperature tensile and impact properties, stress-rupture properties, elevated-temperature oxidation resistance, and metallographic and X-ray studies are reported for arc-melted alloys. Data are tabulated and plotted.—BLR.

6.3.18

Vanadium Metal — A New Article of Commerce. A. B. Kinzel. *Metal Progress,* **58.** 315-321, 344-B (1950) Sept.

Director of research program on production, fabrication, properties and engineering possibilities of high-purity vanadium at Electro-Metallurgical Div., Union Carbide and Carbon Corp., describes present status and discusses future prospects. Data sheet tabulates and charts physical and mechanical properties, also corrosion resistance.—BLR.

6.3.20, 3.7.4

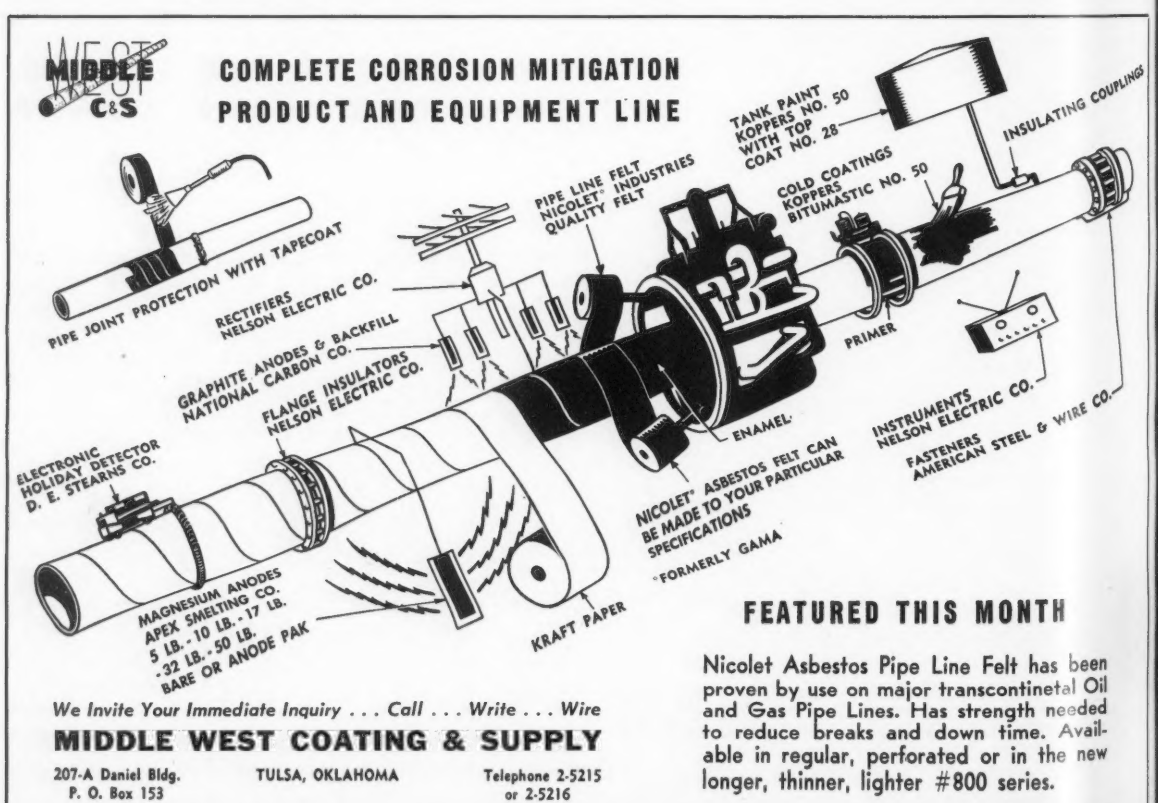
Constitution and Mechanical Properties of Zirconium-Iron Alloys. E. T. Hayes, A. H. Roberson, and W. L. O'Brien. Northwest Electrodevelopment Lab. Paper before Am. Soc. Metals 32nd Ann. Conv., Chicago, Oct. 23-27, 1950. Am. Soc. Metals, Preprint No. 29, 17 pp., 1950.

A diagram for the zirconium-iron system has been developed which shows a eutectoid at 2.5 iron and 1470° F and a eutectic at 16 iron and 1715° F. The maximum solubility of iron in β zirconium is 5.5 iron. Solubility in α, or hexagonal, is less than 0.02 iron. Alloys containing up to 7 iron can be worked at 1560° F when protected from oxidation. Tensile data, heat resistance below 1020° F and hot strength are given for hot-rolled, quenched, drawn and cold-worked alloys. Some alloys are age-hardenable. Photomicrographs show typical structures.—INCO.

6.3.20, 3.5.9, 4.6.2

Heat-Resistance of Zirconium in Several Mediums. E. T. Hayes, A. H. Roberson, and R. H. Robertson. *J. Electrochem. Soc.,* **97,** No. 10, 316-323 (1950).

Zirconium sheet was heated in carbon dioxide, carbon monoxide, hydrogen, sulfur dioxide, propane and steam at atmospheric pressure. Weight changes and tensile properties were determined, the metallographic structures were examined, and the safe heating temperature for the metal exposed to the various gases were deduced. A somewhat high maximum allowable corrosion rate was chosen—0.1-in. per year. The time of heating was 24 hr and it is not therefore possible to get a reliable idea of how the metal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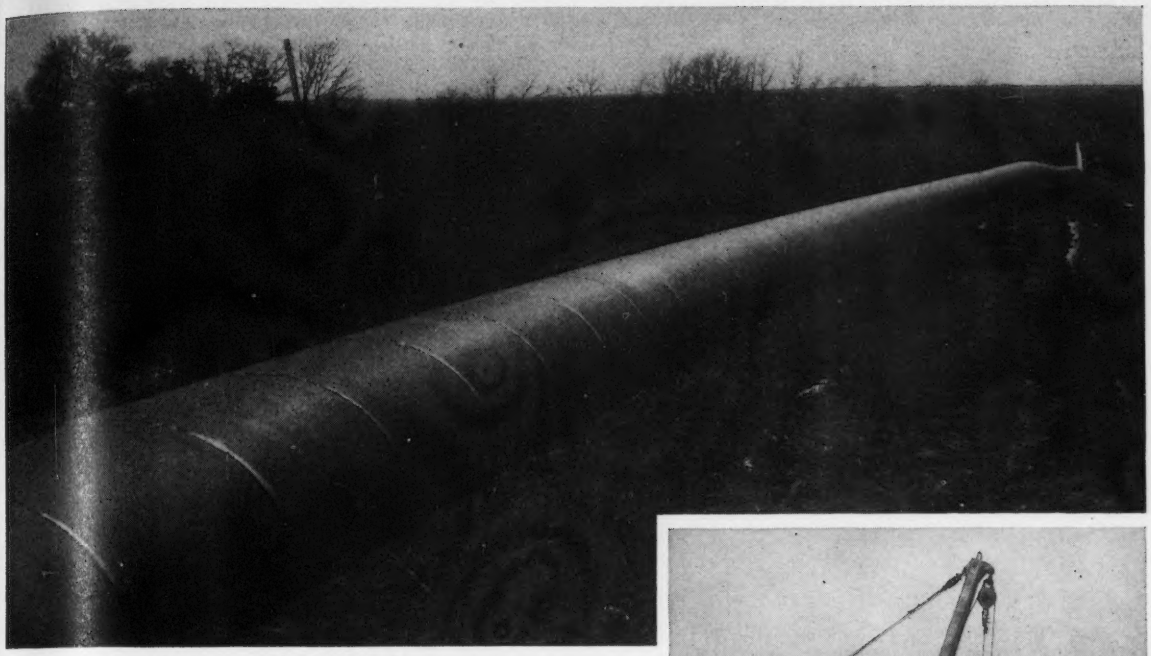

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would behave over long periods of exposure. The following summarizes the results obtained. 1) In carbon dioxide the metal should not be heated above 650° C. Tensile properties are impaired at 800° C. 2) In carbon monoxide, 900° C for 1 hr and 700° C for 24 hr are the maximum permissible temperature. Maximum tensile strength was obtained in specimens heated at 800° C for 24 hr. 3) Specimens heated in sulfur dioxide to 600° C. 4) There was a marked deterioration in tensile properties on heating in hydrogen at above 500° C for 24 hr. 5) Heating in propane to 900° C did not impair the yield or ultimate tensile strengths, but elongation was reduced at 800° C and above. There was hydride formation. 6) Steam produced a very high corrosion rate, though less than sulfur dioxide. The metal should not be used in contact with steam above 600° C.—MA.

6.3.20, 3.5.9, 3.4.6

The Oxidation of Zirconium at High Temperatures. Daniel Cubicciotti. *J. Am. Chem. Soc.*, **72**, No. 9, 4138-4141 (1950).

In a study of the rate consumption of oxygen by ductile zirconium metal in the range 600° - 920° C the oxidation curves obtained were parabolic at all temperatures except 920° C., where a small deviation towards linear was observed. Change of oxygen pressure from 0.1 to 20 cm mercury had no effect on the oxidation rates. The temperature coefficient of the parabolic rate constant gave an activation energy of 32 kg. cal. per mole.—MA.

6.4 Non-Ferrous Metals and Alloys—Light

6.4.2, 7.7

Aluminum for Electrical Conductors. *Light Metals* (England), **12**, No. 142, 614-626 (1949) Nov.

A constant problem in the development of aluminum for electrical conductors was means of preserving the high conductivity and good corrosion resistance characteristics of the metal and yet maintaining mechanical properties suitable for its use in this application. After much research an alloy system was developed which effected a compromise between the requisite mechanical strength and corrosion resistance, and an electrical conductivity of some 10 percent less than that of unalloyed aluminum. The alloys developed belong to the magnesium-silicide group and are to be found on the market under the names Aldrey, Almelec and Aludur. Work is being done to produce alloys with as good electrical conductivity as this group but with yet greater mechanical strength and easiness of fabrication.—ALL.

6.4.2, 8.1.2, 5.4.5

Aluminium Bungalows — Ministry of Health's Recommendations on Repainting. *Illustrated Carpenter and Builder* (England), **139**, 1412 (1950) Sept. 8. *Decorator* (England), **49**, 57-58 (1950) Sept. 15.

Recommendations to local authorities on the method of repainting aluminum bungalows are contained in a memorandum issued by the Ministry of Health. Regarding walls, particular and early attention should be paid to the condition of the extruded members and cover strips. Structural members, such as exposed wall and chassis members and vertical corner members, together with the cover strips, must be carefully examined for paint failure as they are more liable to corrosion than the Alclad sheeting. The latter must not be scratched, and the use of metal scrapers and wire brushes should be avoided. Painting should include one coat of a high-hiding linseed oil paint, and perhaps a second after 24 hours. Roofs have hitherto not been painted, and generally should not require such protection for some time. The procedure recommended is to wash and brush down with a bristle brush, brush on one coat of zinc chromate-red oxide primer, dry for 16 hours, and apply one coat of any good exterior paint.—ALL.

6.4.2

Aluminum Nails Gain Favour Among Users. *Iron Age* (U.S.A.), **166**, No. 18, 106 (1950) Nov. 2.

With the impetus of the steel shortage in 1948, the use of aluminum nails has grown steadily with the results that in 1949 there were twice as many nails made of aluminum than other non-ferrous metals. First used as a substitute, this status has been replaced due to their own characteristics of: 1) freeness from rust and resistance to stain; 2) no galvanic action when used with aluminum roofing and siding; 3) light weight; 4) attractive appearance; and 5) cheapness compared to other nonferrous nails. There are almost three times as many aluminum nails per pound as there are in a pound of either steel or other nonferrous nails. The use of aluminum nails eliminates the necessity of countersinking and puttying.—ALL.

6.4.5, 3.7.3

Nitriding the Martensitic Stainless Steels. Part II. (Concluded.) Howard E. Boyer. *Steel Processing*, **36**, 403-407+ (1950) Aug.

Study of microstructures from specimens of each type tends to substantiate results shown by the depth-hardness charts, as well as statements made in Part I. 48-hr. salt-spray test specimens following different heat treatments are illustrated and discussed.—BLR.

6.4.4

Magnesium (Elektron) Casting Alloys. (In English.) L. J. G. Van Ewijk. International Gieterij Congres 1949-Amsterdam, 79-88 (TS 200 In8g.)

Describes corrosion resistance, fire risk, mechanical properties and foundry technique. Includes tables and photographs.—BLR.

6.4.4

The Truth About Magnesium. Capt. G. W. Orton. USAF. *Modern Metals*, **7**, No. 2, 52-53 (1951) Mar.

Some people say magnesium cracks without provocation; some say it readily ignites; others say it has no resistance to corrosion. These criticisms are serious and should be examined by designers, fabricators and users of any material. With experience and "know how," magnesium may be readily shaped by any common process without the danger of cracking. It must, however, be handled as a new metal and not in the same manner as aluminum, steel or brass. Atmospheric tests and service experience have shown that magnesium alloy parts may be used for years with no ill effects from corrosion. The use made of magnesium at one time for the manufacture of incendiary bombs has created a more or less general fear of the danger involved in its burning. It should be remembered that all finely divided metals will burn when in contact with oxygen or oxygen-producing chemicals and many different metals are used for this purpose. Desirable characteristics include light weight, high-strength, unexcelled machinability, the ability to be worked by all common methods, stability in many atmospheres and other advantages important in the mass production of strong materials during national emergencies. As a material magnesium has proven itself. Any difficulty encountered is a problem of technique in handling, processing, or finishing the material, not in the magnesium itself.—TDD.

6.4.2, 4.6.11

Exposure to Salt Water Proves Life of Die Cast Aluminum. *Die Castings*, 8, No. 8, 32-34 (1950) Aug.

Use of die cast aluminum, stainless steel stampings and stainless capped bolts for marine devices instead of sand casting in aluminum and brass has been found to increase corrosion resistance. A high silicon alloy (SAE Alloy 306) is used. The aluminum die castings are given a Bonderizing treatment which increases their ability to withstand chemical attack by creating an inert surface. The use of die cast has reduced machining and eliminated jig drilling. Illustrations are shown.—INCO.

6.4.4, 3.7.3

Aging Characteristics of Magnesium-Lithium Base Alloys. P. D. Frost, J. G. Kura, and L. W. Eastwood. *J. Metals*, **188**, 1277-1282 (1950) Oct.

Although magnesium-lithium base alloys have several desirable properties, they also possess certain undesirable characteristics, one of which is the tendency to over-age at 150°-200° F. This problem is discussed. Recently developed alloys are described which possess stability of properties at 200° F nearly equal to that of commercial magnesium alloys. Data tabulated and charted include stress-corrosion resistance in an industrial atmosphere, formability and tensile properties.—BLR.

6.4.4

Commercial Uses of Magnesium in Germany. E. J. DeRidder. *Modern Metals*, **6**, No. 8, 29-32 (1950) Sept.

Studies were made of the commercial uses of magnesium in Germany. It was found that magnesium is particularly well suited to all types of heavy stationary machines containing reciprocating parts and rotating parts that undergo frequent braking. The considerable weight reduction greatly increases the capacity of the machines and permits a significant power saving. The use of magnesium in the main bodies of machine tools was practicable in just a few cases, such as portable work shops and in cases where the machinery was on upper floors because floor loading was limited. A few of the more important applications of magnesium are discussed to illustrate the great versatility of this lightest of all structural metals. These includes cranes and dredges, printing presses and plates, textile machines, the electrical and optical industries, office machines and domestic appliances.—TDD.

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6.4.2, 8.8.1

Welded Aluminum Ammonium Nitrate Prilling Tower. H. N. Hockensmith. *Welding J.*, **29**, No. 9, 729-732 (1950) Sept.

Production of equipment of 61S aluminum-1 manganese-0.6 silicon-0.25 copper-0.25 chromium; claimed to be able to withstand severe service conditions involving strength, fatigue, corrosion and temperature changes. In the tower described, ammonium nitrate solution sprayed from the top meets a rising stream of cold air and is converted into "prills" (or pellets) of the solid; it is essential that the inside of the tower be mirror-smooth.—BNF.

6.6 Non-Metallic Materials

6.6.8

Hot Gas Welding of Plastics. J. A. NEUMANN. Amer. Agile Corp. *Modern Plastics*, **23**, No. 3, 97-102 (1950) Nov.

Methods and techniques used in plastics welding are described. The bases of these processes are the facts that thermoplastics soften and can be brought to coalescence when heated and that the original rigidity is regained upon cooling. The equipment used in welding plastics consists of a hot-gas or "flameless" torch pressure regulator and filler rod. Plastic welds resemble the types produced by electric arc welding. For the fillet weld, no preparation is needed. For the butt weld, the two pieces are bevelled in a manner used in arc welding, but a smaller angle, namely 60° to 80°, and with no sharp edges. With plastics, a simple bonding process takes place between filler rod and material, since only the actual meeting surfaces melt; the other parts such as the center of the rod remain relatively unaffected and rigid. The costs for plastic welding can be compared with those for metal welding, except that electrical or gas consumption is appreciably lower because plastics have a melting point which is radically lower than welding rod for metal. Successful uses for welded plastics have been found in the chemical and food industries, in laundries and breweries and wherever acids and strong alkalies are present.—TDD.

6.6.8, 4.3.2, 2.3.4

Resistance of Representative Plastic Materials to Hydrofluoric Acid. F. W. REINHART AND H. C. WILLIAMS, JR. Natl. Bur. Standards. *ASTM Bul.*, **1950**, No. 167, 60-62, July.

A number of plastics were tested for their resistance to hydrofluoric acid. Materials tested were molded pieces of polyvinyl chloride acetate, polystyrene, polymethyl methacrylate, cellulose acetate, urea-formaldehyde, melamine- formaldehyde and polyethylene plastics, as well as pieces of phenolic paper, phenolic cotton fabric, phenolic asbestos and unsaturated polyester glass-fabric laminates with machined edges. The specimens were conditioned at 25° C and 50 percent relative humidity for at lease 14 days and then weighed and measured. The specimens were placed on edge in large glass test tubes containing approximately 150 ml of 48 percent hydrofluoric acid. On removal from the hydrofluoric acid, the specimens were rinsed with distilled water, wiped dry, and conditioned for 24 hr before being weighed and measured. Results showed that urea-formaldehyde and cellulose acetate are soluble at room temperature in 48 percent hydrofluoric acid. The phenolic and the melamine laminate plastics were appreciably affected in less than one week. Polymethyl methacrylate plastics became swollen, rubbery and milky. Resistance of polystyrene was outstanding. Polyethylene and vinyl chloride acetate plastics were affected only slightly. —TDD.

6.6.8, 8.9.1

Plastics in Aircraft. K. GREER. *Aeroplane*, **80**, No. 2065, 216-217 (1951) Feb. 16.

Applications for which plastics are used in the aircraft industry are not generally spectacular and it is doubtful if more than a few of the people who travel by air are aware that plastics play any part at all in aircraft construction. Nevertheless, plastics are used in considerable quantities in both civil and military aircraft, being chosen by designers on the basis of technical performance. From the user's point of view, it is convenient to regard plastics as falling into two categories, the thermosetting resins and the thermoplastics resins. Thermosetting resins are materials which, under the influence of heat and pressure, can be molded to a required shape, and which, as a result of this treatment, become hard. Under the influence of further heating there is no tendency to revert to their original form. Thermoplastic resins, on the other hand, soften when heated and become rubber-like, and in this condition can be molded or shaped. On cooling, the material freezes and retains the shape into which it has been formed, but subsequent heating causes it to revert to its original form and the article can, in some cases, be remodeled to the same or another shape. There are five main types of plastics of interest to the aircraft industry. Three of these are thermoplastics — acrylic plastics, polyvinyl chloride, and polythene; the other two are the thermosetting resins, and the low-pressure laminating resins in the same category. The author presents in this article a concise guide, in nontechnical language, to the properties of the various types of these plastic materials, and the parts they are most suited to play in aircraft.—TDD.

6.6.8

Rubber-Phenolic Materials for Greater Impact Strength. W. Goss. GE Co. *Product Engineering*, **1951**, 137-141, Jan.

Phenolic molding materials are produced in a wide variety of formulations to fill many different property needs. In addition to the general purpose grades, there are specially developed phenolic compositions for faster cure, better finish, improved mold release, heat resistance, improved electrical properties, lower molding pressures and higher impact strength. Compounds of the impact resistant grades have greater impact strengths than the so-called general-purpose grades but fall short of requirements in many industrial applications, especially where vibration and fatigue are associated with shock. Use of fabric fillers can improve shock resistance of phenolics up to a point. It became apparent that a more resilient material—like rubber—should be added to retain the inherent strength of phenolics, but at the same time lessen their brittleness. The combination of phenol-formaldehyde resins and synthetic rubber for molding compositions offers a series of materials with more desirable resistance to abuse than standard phenolics, without sacrificing moldability bulk factor, or other highly desirable characteristics of standard phenolic molding powders. Natural rubbers and phenolic resins are not compatible. American synthetic rubbers, however, are more compatible with phenolic resins. Physical and chemical properties of these new materials, compared with their straight phenolic counterparts are tabulated. Comparative costs of compounds in cents per cubic inch are given. Advantages claimed for the use of rubber-phenolic materials are listed and the applications and the molding and design of these materials are discussed in detail.—TDD.

6.6.8

Descriptions of Grades of Laminated Thermosetting Materials. *Design News*, **1950, 67,** Sept.

Four types and 16 grades of laminated thermosetting material are described. The types and grades of materials are classified in accordance with the sheet filler employed in their manufacture, and the electrical, mechanical and heat-resisting properties of the finished product. The types are cellulose paper-base laminates, fabric-base laminates, asbestos-base laminates and glass-base laminates. The grades consist of two or more plies or layers of sheet filler bonded by a thermosetting type of two or more plies or layers of sheet filler bonded by a thermosetting type of synthetic resin. Laminated thermosetting material offers the following properties, though the values may vary over a fairly wide range: light weight, usually about half that of aluminum; favorable weight-strength ratio in compression, tension, flexure, impact, shear and torsion over a temperature range from subzero to 250° F; good dimensional stability throughout the temperature range; excellent moisture resistance; high dielectric strength; low heat-conductivity; good decorative potentialities; and inertness to many common reagents and solvents.—TDD.

6.6.8, 7.7

Plastics in Cable Manufacture. D. C. Hancock. *British Plastics*, 23, No. 257, 115-121 (1950) Oct.

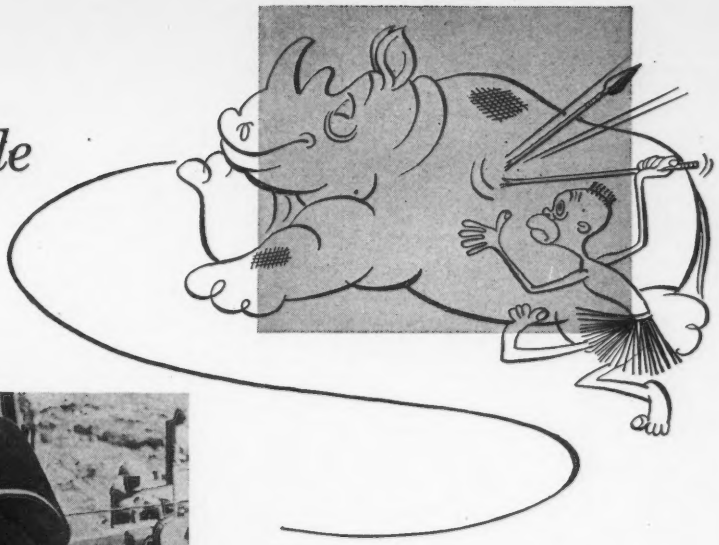
The plastic insulating materials which are discussed are those which are of immediate application in the cable industry. There are other insulating materials which could have been mentioned which will doubtless prove of value in the future. The widespread interest and use of plastics of all types is increasing rapidly, resulting from the close cooperation of the chemists, physicists, and electrical engineers engaged in this field of work and the development and expansion of manufacturing facilities for many types of plastics in this country is especially welcomed. Economic considerations do at present limit the wider use of many of the materials to those applications where the special characteristics are considered essential.—TDD.

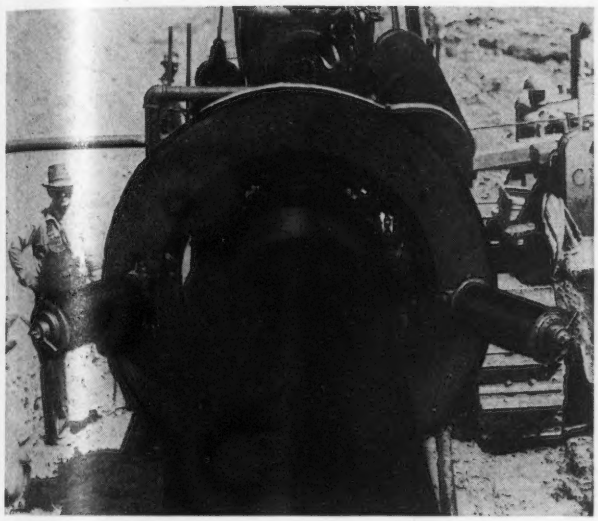
6.6.6

General Properties of Typical Commercial Glasses. *Design News*, **1950,** 63, Sept.

A table is given on which the general properties of typical commercial glasses are listed. Inexpensive lime glasses are used where high heat resistance and chemical stability are not required. Lead glasses are applied for electric-light-bulb stems, neon-sign tubing and some optical parts. They have good hot-working

Like the Rhino's tough hide that protects what's inside...





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properties, high electrical resistivity and high refractive indexes. Borosilicate glasses are used for chemical laboratory glassware, boiler gage glasses and pipe. This glass has high chemical stability, a low coefficient for thermal expansion, high-heat shock resistance and good electrical resistivity. High silica glass is made by chemically removing the flux from a borosilicate glass after it has been melted and formed. It is an expensive glass but can be used regularly at temperatures up to 800° C and can withstand the most severe thermal shocks. The table indicates the forms of the glass types usually available, their color, principal use, glass code, the thermal expansion coefficient, the approximate upper working temperatures, thermal shock resistance, viscosity data, relative resistance to sand blasting, density, modulus of elasticity, $\log_{10}$ of volume resistivity, dielectric properties and refractive index. —TDD.

6.6.6

Ceramics. John H. Koenig and Robert H. Thomas. *Ind. and Eng. Chem.*, **42**, 1961-1970 (1950) Oct.

Reviews developments during the past year in a number of different types of ceramics, enamel and glass products, whitewares, refractories and structural claywares. Table and illustrations. Includes porcelain enameling.—BLR.

6.6.6

Ceramics for Engineering Applications. J. H. Koenig. Rutgers Univ. Materials & Methods Manual No. 62. *Materials & Methods*, **32**, No. 3, 69-84 (1950) Sept.

A comprehensive picture of technical ceramics give composition, properties and uses of commercial and special purpose refractories for electrical, chemical and high temperature purposes.

6.6.11, 7.10

Equipment and Design. C. O. Brown. *Ind. and Eng. Chem.*, **42**, No. 9, 103A-104A (1950) Sept.

Wood, impregnated wood and plastics are suggested as substitues for steel in the construction of many types of chemical equipment. The hardness of wood has recently been greatly increased by impregnation with organic compounds, such as dimethylurea, into the fiber and then setting the compound with heat and pressure. In some cases, articles can be fabricated as plain, soft, dry wood, and then impregnated and set. Wood has been used quite generally for agitation and storage tanks throughout the chemical, food, and beverage industries. Wood construction can be lined with special sheet materials, such as rubber, tin, and plastics, for anticorrosion uses and where contamination of chemicals with heavy metals is to be avoided. Wood could be used to advantage in a stripping tower and in the cyclone-type separator. A new type of nonmetallic construction is a combination of glass fibers and certain plastics to produce tubes and small vessels of unusual strength.—TDD.

6.7 Duplex Materials

6.7.2

Problems in Powder Metallurgy. H. W. GREENWOOD. Powder Metallurgy, Ltd. *Metallurgia*, **42**, No. 251, 176-178 (1950) Sept.

Problems in powder metallurgical technique were examined. These include a need for greater strength as measured by yield point and tensile as well as greater resistance to high temperature. Investigations with combinations of metals and nonmetallic refractories offer solutions to these problems. The most fruitful field in the last few years, in learning to increase and more accurately control the physical properties of certain metals and compounds, has been that of infiltrating sintered and porous bodies with another metal. Another line of attack on the problem is in the use of combinations of metals and nonmetallic refractories or cermets. Both of these techniques are described briefly.—TDD.

6.7.2, 7.10, 3.5.9

Thermal Shock No Problem for New Metal Ceramic. W. O. SWEENY. Union Carbide and Carbon Corp. *Steel*, **127**, No. 6, 88-89 (1950) Aug. 7.

Tubes of a new metal-ceramic can be plunged into molten steel and withstand the thermal shock of going from room temperature to 2800°-3000° F without attack from slag or metal. Thermocouple protection tubes for immersion in molten steel, cast iron, brass, bronze, and other metals except aluminum have shown up well on test. The material has good resistance to oxidation. It has been tested in several parts for ram jets and gas turbine nozzles of this material will permit higher gas temperature.—INCO.

7. EQUIPMENT

7.1 Engines, Bearings and Turbines

7.1

Sulphur-Containing Exhaust Gases of Internal Combustion Engines. M. F. Van der Zijden, F. E. Van Hinte, and F. C. Van den Ende. *J. Inst. Petroleum*, **36**, 561-574 (1950) Sept.

Starting from the assumption that knowledge of the sulfur-oxide content of exhaust gases would assist the study of the influence of sulfur trioxide on wear and fouling of internal-combustion engines, the sulfur trioxide-content of exhaust gases of some spark-ignition and Diesel engines was determined by the authors. The quantity of sulfur trioxide present was found to be very low in all cases, by far the greater part of the sulfur being present as sulfur dioxide. The correct determination of sulfur dioxide in addition to sulfur trioxide in the exhaust gas is, however, very difficult, because sulfur dioxide is rapidly oxidized during sampling and analyzing due to compounds of the peroxide type present in the exhaust gas and to water. Oxidation will also occur on cold cylinder walls and the sulfur trioxide thus formed is considered as a main source of wear and fouling of engines. The authors found that there was obviously no relation between the true sulfur trioxide-content of the exhaust gas and the sulfur trioxide found on the cylinder walls, and sulfur trioxide-determinations of the exhaust gas were therefore of little use for the wear and fouling problem of engines.—TIME.

7.1, 4.6.4

Radial Type Engines and Corrosion Discussed by ASME—Baltimore. Symposium before ASME, Oil and Gas Power Div. Mtg., Baltimore. *So. Power & Industry*, **68**, No. 8, 60-61+ (1950) Aug.

Papers discussed are: Fundamentals of Corrosion by R. H. Mears; Corrosion on the Water-Side of Internal-Combustion Engines by J. F. Wilkes (Dearborn Chem. Co.); Corrosion on the Combustion Side of Internal Combustion Engines by A. R. Schrader and Design Features of the New Nordberg Radial Diesel 120 by E. Grieshaber (Nordberg Mfg. Co.) and D. I. Bohn.—INCO.

7.1, 4.3.2, 3.5.8

Effect of Hydrogen Sulfide on Turbine Blades. A. Splittgerber. *Vom Wasser*, 17, 140 (1949).

Cracks observed on turbine blades in power plants traced to combined effect of stress and corrosion. Both intercryst. and intracryst. cracks found in all parts of blades in turbine stages where transition from superheated to satd. steam took place. All blades consisted of 5 percent nickel-steel. Corrosion caused mainly by action of hydrogen sulfide formed by decompn. of sodium sulfite at superheating temps. above 275°. Sodium sulfite has been used for degassing of boiler feedwater. Hydrogen sulfide could also be formed by reduction of sodium sulfate contained in feedwaters of low alky. Increase in sulfur content from 0.006 to 0.028 percent detd. in material sections showing intercryst. cracks. Exposure tests with pure nickel, showed crack formation at hydrogen sulfide concns. as low as 0.004 percent. Time tests on blades of 5 percent nickel-steel with use of feedwater contg. 0.001, 0.01 and 0.03 ppm of hydrogen sulfide showed universal microscopic crack formation.—PR.

7.1, 3.5.3, 7.6.4

Erosion and Corrosion Accompanying the Use of Heavy Fuel Oils as Engine, Boiler and Gas Turbine Fuels. (In German.) B. Engel. *Erdol u. Kohle*, **3**, 321-327 (1950) July.

Presents a detailed study on causes of the above. Specific suggestions for reducing or preventing such attack are presented. Data are tabulated.—BLR.

7.1

Sulphur Content of Diesel Fuels. E. W. Steinitz. *Petroleum*, **13**, 200-201 (1950) Aug.

Diesel engines as used on board ships are today one of the most reliable sources of power and no interference has been observed since the introduction of fuels with higher sulfur content. The higher sulfur content in marine Diesel fuel is a fact, and sulfur has been found at the rate of 3 percent and even 4 percent. The reason ships' Diesels show no troubles is, first, that they are slow runners, with engine speeds ranging from 100 to 120 rpm. In addition, these large, slow-running units have special lubricators for the cylinder walls so that the right amount of oil can be introduced into the right place. Furthermore, the cylinder walls are very thick so that their temperature can be kept above the dew point of the combustion gases and there is no danger of corrosion and cylinder wear.—TIME.

7.1, 5.7.9

Protection of Gas Turbines. *Eng. Digest*, **11**, 375 (1950) Nov.

Corrosion and the production of heavy deposits in gas turbines by lower grade fuel oils is eliminated by passing the combustion gases through a separator where they are cooled from a tempera-

ture just above the dewpoint to one just below it, so that harmful vapors are condensed and can be removed before entering the turbine. The introduction of a spray of sea water into the separating chamber promotes the catalytic deposition of vanadium pentoxide.

7.1, 7.2

Five Diesel Valves Troubles. V. Ayres. Eaton Mfg. Co. Paper before SAE, Summer Mtg., French Lick, Ind., June 6, 1950. *SAE J.*, **58**, No. 9, 58-63 (1950) Sept.

The paper discusses the cause and remedy of Diesel valve troubles. The discussion includes seat wear and guttering surfaces, valve breakage, structure, materials and sticking, graphical vs. harmonic design, fuel deposits and stem and guide wear. The majority of Diesel exhaust valves are made of austenitic steels. The use of N_2-bearing 21-12 reduces dishing and breaking where Silchrome No. 1, x-be or xcr, will stretch, dish or break in some engine operating conditions. Materials to reduce wear are limited to cast iron for the seat, unless a seat insert or valve materials are used. Carbon or low alloy steels have a scaling loss of 20,000 mg. per 200 hours, valve steels of 30-50 mg. per 200 hours and stellite and eatonite have values less than 20 mg. per 200 hours.—INCO.

7.2 Valves, Pipes and Meters

7.2, 4.3.6, 3.2.2

Observations of Corrosion in Liquid Pumps. W. Katz. (In German.) *Metalloberflache, Ausgabe A*, **4**, No. 9, A136 (1950) Sept.

Some places where corrosion of cast iron and various copper alloy parts may occur in pumps for different salt solutions; types of corrosion and damage caused.—BNF.

7.3 Pumps, Compressors, Propellers, Impellers

7.3, 3.5.8

Stress Corrosion in a Stainless Steel Compressor. F. W. Davis. *Trans. Am. Soc. Metals*, **42**, 1233-1259 (1950).—MI.

7.3, 2.3.8, 6.5

Corrosion-Erosion of Boiler Feed Pumps. *Eng. and Boiler House Rev.*, **65**, 151 (1950) May.

Report of tests by Detroit Edison Co., to obtain data applicable to present-day conditions of high feed-water temperatures. Measurements of resistance to corrosion-erosion of Navy M bronze, three chromium steels, a chromium-molybdenum steel, a molybdenum steel, 0.24 percent carbon steel, leaded bronze, and chromium-plated surfaces are given. Method of test to simulate service conditions is described.—INCO.

7.3, 5.3.2

Corrosion of Propeller Shafts. L. Fea, G. Guidi and M. Raffo. *Riv. Marittima*, **82**, 558-581 (1950) June.

This article reviews ways and means of combating propeller shaft damage by corrosion. Special reference is made to the research conducted by C. Manzitti

A regular service of The **COOPER ALLOY** Foundry Co., Hillside, N. J.

TECHNICAL TOPICS

RUST FORMATION ON 18-8 STAINLESS STEEL

NORMAN S. MOTT
Chief Chemist and Metallurgist

The popular conception that rust can never form on 18-8 stainless steel unless something is wrong with the chemical composition or the heat treatment, is a long way from the truth. Experience has shown that rust can occur on stainless alloys of controlled composition and heat treatment as the result of surface contamination. Among the many sources of contamination which may contribute to the formation of rust on the surface of stainless steels, the following are leading offenders:

1. An iron film left on the surface as the result of a machining or other manufacturing operation will tend to rust in the presence of moisture.
2. Microscopic scale particles left on the surface after pickling may become visible as "rust" under suitable conditions.
3. Pickling solution oozing from minute pores in the metal may stain the surface and oxidize to a brown rust color due to the iron which it contains.
4. The accumulation of the natural corrosion products of the alloy in corrosive service on a rough surface may cause a brown stain due to oxidation.
5. Discoloration may be caused by the accumulation of any extraneous processing material which is of such a nature as to cause a "rusty" appearance on a rough surface.

Articles that are to have a truly "stainless" appearance should have all scale completely removed by suitable cleaning methods, should be passivated after machining operations in warm dilute nitric acid, should be free from porosity, and should have a reasonably smooth surface.

A smooth or polished surface will always stay cleaner and brighter, and be more resistant under mildly corrosive conditions than a rough surface and this tendency increases with the degree of polish. Although it is true that stainless steel is at its best when highly polished, it should be remembered that under strongly corrosive conditions this polish is soon removed. For most applications, it is the inherent resistance of the alloy that counts and "rust" conditions such as those described are relatively harmless. They are the results of surface contamination and in no way reflect the composition of the alloy or the effectiveness of the heat treatment.

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in the years 1933-1936. The latter was in charge of an investigation concerned with the damage by corrosion of the propeller shafts of the quadruple screw motorship Victoria owned by the Lloyd Triestino. The remedial measure applied was the rebuilding of the affected parts adjoining the bronze liners by applying a sprayed-on layer of nickel which proved sacrificial in service thus affording protection to the shafting. A potentiometric circuit devised to drain off stray currents from the propeller shafts was also installed.—TIME.

7.5 Containers

7.5.5, 8.9.3

How to Prevent Storage Tank Corrosion. *Petroleum Refiner,* **29,** No. 9, 241-242 (1950) Sept.

Method to prevent corrosion in storage tanks containing crude petroleum uses a glass fiber pipe wrap material and coal tar blend enamel. The procedure, consisting of 9 steps, is illustrated.—INCO.

7.5.1, 6.2.2

Design of Light Metal Tanks and Containers. (In Hungarian). Pal Vojnich. *Aluminium* (Budapest), **2,** No. 5, 121-130 (1950).

The advantages to be gained by the use of aluminum-base light-metal tanks and cylinders for the storage and transportation of industrial gases (oxygen, acetylene, etc.), petroleum products, oil, beer and milk, etc., are not only a 50-60 percent saving in weight but a much improved heat insulation, resulting from the high reflectivity of the surface for heat and other rays; also the salts of aluminum are colorless and completely innocuous. Hints and formulae are given for the designing of containers of all kinds and several applications in different branches of industry are illustrated. —MA.

7.6 Unit Process Equipment

7.6.8, 8.4.3, 6.2.5

Bubble Trays — Design and Layout. J. A. Davies. Texas Co. *Petroleum Refiner,* **29,** No. 8, 93-98 (1950) Aug.; No. 9, 121-130. Sept.

Sufficient information on practice, theory, and procedure is given so that the relatively inexperienced plant process man can design satisfactory trays. A list of common metals used in tray construction and their cost ratio includes, stainless steel, Monel, Inconel and hastelloy. In the petroleum industry where mild corrosion normally occurs, steel containing 11-13 chromium are widely used, especially as trays because gauge metal trays are considerably lighter than cast or welded trays and as such are easier to handle and install in the tower.—INCO.

7.6, 3.5, 4.6

Experimental Studies of Iron Oxide Deposits in Boilers. C. Jacklin and H. Thompson. Paper, 12th Ann. Midwest Power Conf., Chicago, Apr. 5, 1950; abstr. *Combustion,* **21,** No. 10, 49 (1950) Apr.

In boilers having localized high heat transfer and probable water starved areas, high boiler-water alkalinity is undesirable. Iron in the boiler water speeds the rate of corrosion.

7.6.4, 4.2.3

Damage to Superheaters and Air Preheaters With Oil Firing. H. Liender. *Combustion,* **22,** 47-50 (1950) Sept. Translated from Teknisk Tidskrift.

Describes and illustrates severe damage which occurred in two distinct forms in boilers of a Swedish power station due to flue-gas contact. The first was straight corrosion of stainless steels; the second was caused by burning of an oil deposit which caused actual melting of the steel.—BLR.

7.6.9, 5.4.5

New American Blast Furnace Designed for Carbon Lining. H. A. Brassert. H. A. Brassert Co. *Iron Age,* 166, No. 12, 92-94 (1950) Sept. 21.

A blast furnace designed to use carbon lining inside an all-welded gas tight tank, is described. All water cooling is done on the outside. The furnace has no cooling plates in the hearth, bosh walls or inwall. Higher costs of carbon block are offset by much less copper, piping and maintenance. Greater volume of the furnace within a given shell is achieved by the thinner carbon lining. The entire furnace is of heavy welded construction and has a welded steel inverted dome-shaped bottom. A diagram of the furnace is given.—INCO.

7.6.9, 6.6.6

A Mineralogical Study of the Corrosion of Checker Bricks from Open-Hearth Steel Furnaces. Liang-Ho Su.

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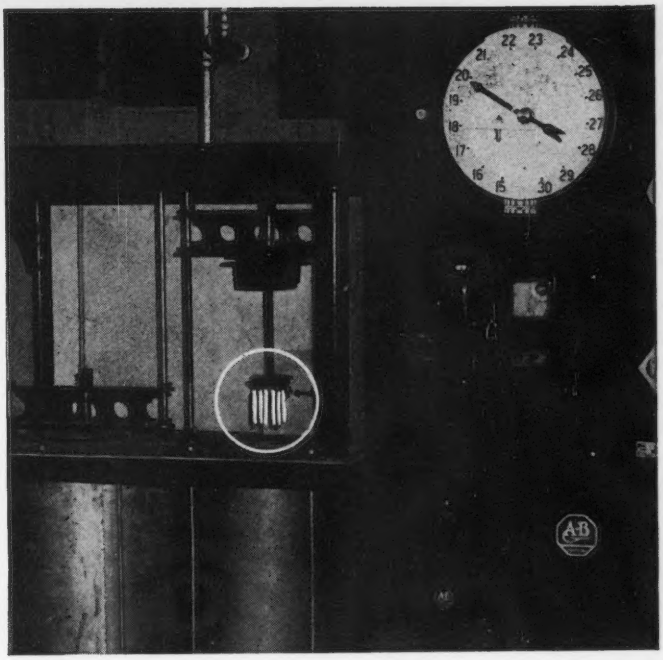


High-Temperature Corrosion Often Is the Main Factor in Metal Failure

Learning why metals fail at high temperatures – determining the actual cause of damage and suggesting as a remedy a more suitable material—these are the jobs of INCO High-Temperature Engineers, who are getting information on such problems for the use of industry.

INCO laboratories in Bayonne, N. J., and Huntington, West Va., have useful data on the properties of metals at elevated temperatures. This information comes from tests made to determine the creep strength, stress-rupture, and other properties of materials at temperatures in some cases up to 2100°F.

Industrial experiences at high temperatures indicate that it is unwise to predict high-temperature performance on the basis of room-temperature properties or short-time high-temperature tests. Other methods have been developed that provide more accurate measures for judging materials.

The machine pictured above was especially designed by INCO Engineers for determining the effect of cyclic heating and cooling on sheet metals while exposed to oxidizing conditions. INCO High-Temperature research likewise covers damage by other corrosive atmospheres. Through work with this and other types of equipment INCO Engineers study the reasons for failure of alloys at high temperatures.

Due to the volume changes accompanying its formation, an oxide film formed at high temperatures on the surface of a metal or alloy is usually under compressive stress. Contraction stresses developed when the underlying metal is cooled further aggravate this situation – and with many alloys may cause rupturing of the normally protective oxide.

Among the factors which influence the resistance to oxidation, the physical characteristics of the formed scale are of importance. The sketches show how these characteristics may cause the breakdown of the scale and thus increase the rate of oxidation.

Blistering may occur in oxide layers having good elasticity but poor adherence to the metal surface.

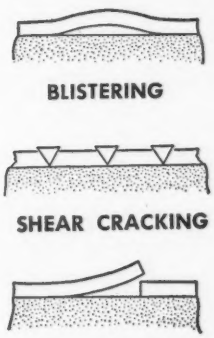
Shear cracking on the other hand will be found in oxides that are adherent but relatively brittle.

Flaking or spalling results when the oxide is both brittle and non-adherent.

As the scale peels away from the metal, it exposes a fresh area to further attack. A point of importance is that the loss of the oxide causes a progressive loss in metal section—useful load-carrying metal.

In high-temperature applications employing sheet or strip, the necessity of obtaining maximum resistance to this form of destruction by selection of a suitable heat-resisting alloy is of greatest importance.

Oxide Scale Breakdown by:



If high-temperature alloy performance is a problem to you, whether in present activities or in new projects, INCO High-Temperature Engineers will do their best to be of help to you. Let them send you the *High-Temperature Work Sheet* . . . it is a big aid in explaining your situation fully. Then see if INCO Engineers cannot help solve your difficulty.

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Trans. British Ceramic Society, **49,** 420-453 (1950) Oct.

Corroded bricks from the regenerators of two open-hearth furnaces were studied. The phases present in the corrosion products were identified by microscopic and X-ray methods. Six complete quantitative chemical analyses were carried out. Development of the corrosion process is discussed.—BLR.

7.7 Electrical, Telephone and Radio

7.7, 8.2.2

Aluminum Sub-Station Design: Economic Considerations. B. J. Fletcher and L. T. Guess. *Electric Light and Power* (U.S.A.), **27,** 78+, 152+ (1949) Nov.

The use of aluminum alloy structural shapes for all or most parts of outdoor sub-station structures (columns, beams, trusses) and their fabrication are discussed. Where maintenance of the structure is a serious item, as in industrial and sea-coast areas, economies are obtained despite the higher initial outlay. No painting is required and field erection is reduced. The over-all cost should be less than twice that of similar galvanized steel structures. The advantages of aluminum for the bus-bar conductors, tubular and channel are discussed. Notes are included on the current-carrying capacity, based on temperature rise and the methods of making the conductor connections. Typical aluminum outdoor sub-stations are illustrated.—ALL.

7.7, 3.3.4

The Effect of Moisture and Fungi on the Electrical Properties of Electronic Hook-Up Wire Insulation. M. P. Gauvey. *Tech. Data Digest,* **16,** No. 1 (1950) Jan.

Evidence of the degrading effect of fungi on the electrical properties of certain representative hook-up wires is presented. This deterioration can be shown only by means of electrical measurements on the wires. In those wires affected, the decrease in surface resistance occurs prior to the time that mold growth is visible. From this it is apparent that subvisual fungus growth produces the decrease. It is obvious that mycological cultural methods, which determine only the resistance of hook-up wire insulation to fungus attack are inadequate for approval of wires used in electronic equipment. Of the electrical characteristics studied, the results of surface resistance measurements indicate very effectively the deteriorating effect of fungus. Use of this method in future evaluation and approval would appear to be practical.—TDD.

7.7, 2.3.2, 2.3.3, 5.4.5

Tropicalisation of Radio and Radar Equipment. W. C. Ellis and M. M. Baldwin. U. S. Air Materiel Command, 1948, Contract No. W33-038-ac-14479.

Various fungicidal lacquers were tested. 75 different fungicidal agents, mainly in a vinyl chloride resin lacquer and a p-phenyl phenol-tung oil varnish were used. Various weathering, abrasion and humidity tests were applied. The Battelle method for evaluating fungicidal efficiency is described and used.—RPI.

7.7, 6.4.2

Cables Sheathed with Aluminum. P. M. Hollingsworth. Paper presented at the Conference Internationale des Grands Reseaux Electriques, Paris (France) 29th June-8th July, 1950. *Light Metals Bull.* (England) **12,** No. 17, 669 (1950) Aug. 18.

Because of the scarcity of lead, attention has been focused on the use of aluminum as a material for cable sheathing, and the author gave details of British experience since 1948 of over 200 miles of power cable for voltages up to and including 11 kv. He showed that no practical difficulties have arisen and that the performance of these cables is, in general, equal and in many cases superior to the performance of equivalent lead-covered cables.—ALL.

7.10 Other

7.10, 5.4

Painting Bridges. G. Riley. *Paint Manuf.,* **19,** No. 12, 418 (1949).

Bridges under the jurisdiction of the New York Harbor Authority are painted on a 7-8 year cycle. The corroded parts are scraped and spotted with red-lead varnish paint and the whole is given one finishing coat of aluminum paint.—RPI.

7.10, 8.8.1

The Plant Notebook. *Chem. Eng.,* **57,** 122-124 (1950) Oct.

"Simplified Visual Flowmeter for Corrosive Gases," Frederick J. Gradisher; "Flow Splitter for Lab Size Fractionating Columns," Walter S. Kirk and Joseph L. Viola, Jr.; "Dilution Nomograph for Certain Aqueous Inorganic Solutions," W. C. Frishe, L. S. Ansell, and H. Samuels; "Simple Way to Determine Volume of a Pipeline Reactor," Anthony P. Massa; and "Liquid Seal for Agitators Holds Corrosive Gases," Daniel T. Hayden.—BLR.

7.10, 5.4.5

New Jersey Turnpike Builders Exhibit a Variety of Piledriving Techniques. *Eng. News Record,* **145,** No. 11, 36 (1950) Sept. 14.

Steel H-piles for Passaic River bridge south-approach piers are being given a rust-preventive coating by the Railroad Waterproofing Co. prior to driving. For their upper 25 ft or so, the H-beams are flame-cleaned, coated with a cold primer and then covered with a hot enamel. The hot material is poured on from a sprinkling can, with sprinkler removed, as the H-beams are rotated to bring all the surfaces up for coating.—INCO.

7.10, 8.4.3

Flange, Gasket and Bolting Materials for Refinery Service. O. L. Lewis. *Oil & Gas J.,* **49,** No. 16, 134+ (1950) Aug. 24.

Stress under working conditions and corrosion resistance are the two primary factors involved in the choice of a flange material. Carbon steel forged flange material A.S.T.M. A-181 is the most commonly used and is limited to flanges of 150-300 lb. primary service ratings and temperatures of 750° F. In this class, for 750°-950° F, A-105 material, which is heat treated for grain refinement, is specified. At higher temperatures to 1000° F, A-182 Grade F1, a carbon-molybdenum steel is used, while above this temperature, A.S.T.M. A-182 Grade F5 (5 chromium, ½ molybdenum) is used. When excessive corrosion or extreme temperatures (1200°-1500° F) are encountered, the A.S.T.M. A-182 Grade F8 which can be obtained with added, niobium (columbium), titanium or molybdenum should be considered. From 900°-1100° F, 5 chromium, ½ molybdenum has a higher creep resistance than the carbon-molybdenum and is more resistant to oxidation and scaling. Carbon-steel to the A-193 Grade B7 chromium-molybdenum is used in the refinery. When elevated temperatures are encountered where creep strength becomes the design basis the most common material is the A-193 Grade B14 chromium-molybdenum-vanadium. Gasket materials are rubber, compressed asbestos, copper, aluminum, iron and combinations of two or more of these materials. Rings are of soft iron or mild steel. Alloy materials come into use only when higher temperaure or corrosion is involved. Spirotallic or Flexitalic gaskets for temperature above 450° F is made of strips of asbestos and steel wound spirally together, mild steel being used to 500° F, 304 stainless from 500°-850° F and 309 stainless above 850° F. Rings for ring-type joints are of soft iron for temperatures to 950° F, where 502 (4-6 chromium, ½ molybdenum) is required. Above 1200° F or for severe corrosion conditions, 410 (11-13 chromium) or 304 (18-8) is used. Graphs on mechanical properties are given.—INCO.

8. INDUSTRIES

8.1 Group 1

8.1.3, 4.6.10

The Care and Maintenance of Refrigeration Equipment. H. S. Hall. *Dairy Inds.,* **15,** 813-821 (1950) Aug.

Characteristics of common refrigerants, refrigeration systems and components, corrosion in brine and example of pinhole attack by calcium chloride brine on stainless-steel heat exchanger plate are discussed. 18-8 with molybdenum was most resistant to brine attack, but not immune. Troublesome conditions are outlined and method for avoiding noted. Notes on copper plating, a phenomenon associated with all halogenated refrigerants containing moisture are given. Copper is dissolved from various parts of the system and is deposited on bright steel surfaces.—INCO.

8.3 Group 3

8.3.5, 7.5.2, 5.9.4

Results of Danish Experience in the Canning of Foodstuffs in Aluminium. Bramsnaes. *Rev. Aluminium,* **161,** 404-407 (1949).

An abstract from Revue Belge des Fermentations et des Industries Alimentaires. B. states that the longest periods of preservation are obtained with anodized cans, or better still, anodized and varnished cans. Experience with various foodstuffs is listed.—MA.

8.3.4

The Accommodation of Aluminum Foil Labels in the Bottle Washing Operation. W. J. Faymonville, Jr. Paper presented at the Annual Meeting of the American Society of Brewing Chemists, Detroit, May 8-11, 1950. *Amer. Brewer* (U.S.A.) **83,** No. 38 (1950) July; *Light Metals Bulletin* (England) 12, No. 18, 711 (1950) Sept. 1.

This paper summarizes the known factors related to the reaction of alumi-

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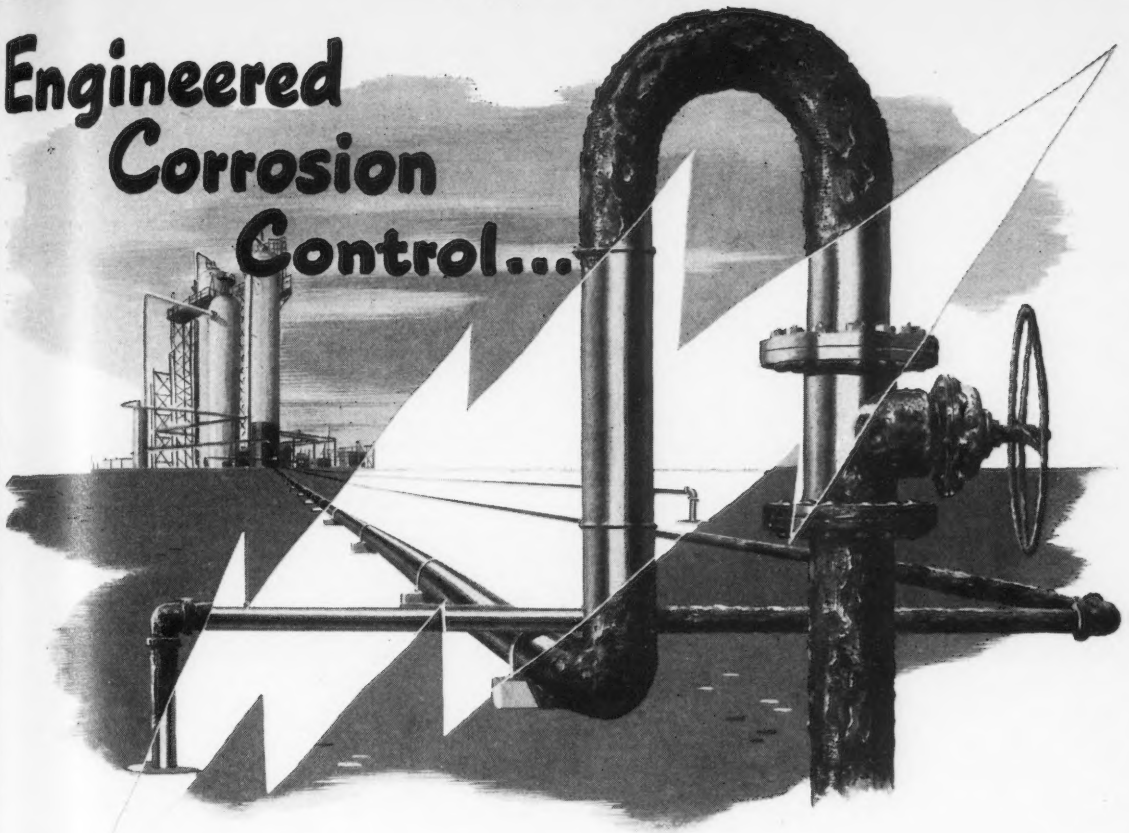

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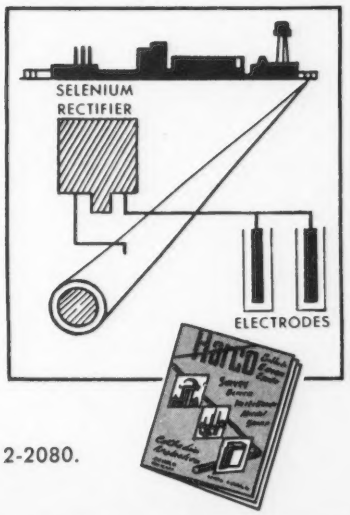

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num labels in bottle washing operations. It attempts to set forth reasons for existing recommendations covering bottle shop procedures in an elementary and consecutive manner, drawing upon both laboratory and field data to substantiate the conclusions offered. The aluminum label is dissected and the subsequent reaction of each component is followed through the washing cycle. Precautions and recommendations are discussed in the order of their logical occurrence in the operation.

Washer practice and techniques, washing compounds, wetting agents and other additives, the formation of aluminum salts and gaseous end products and reclamation of washing solutions are discussed. The paper is frank to admit a glaring deficiency of data covering scale prevention and reclamation procedures, but points the way to possible future theoretical and reasonable approaches to these phases of the subject.—ALL.

8.3.5, 6.4.2, 7.5.2

Uses of Aluminum in Food Preservation and Their Present and Future Problems. (In Hungarian.) Andras Domony. *Aluminium* (Budapest), **2,** No. 4, 89-100 (1950).

Aluminum being readily available and in plentiful supply in Hungary, whereas tin is not always obtainable, great efforts are being made to substitute the former for tinplate and tinfoil in the canning and food-packing industries. In comparing the two materials, the merits and demerits of 99.5 percent aluminum and alloys containing 1.5 percent manganese and 1.5 percent magnesium are listed and briefly discussed. Particular attention is paid to problems connected with the pickling, anodizing, lacquering and airtight closing. Domony is in favor of using chemical methods to obtain a suitable oxide coating and mentions the efforts being made in Hungary to apply the method of supersonic soldering to the last-mentioned problem. Factors influencing the corrosion of aluminum containers depend either on the container itself, e.g. cracks in the lacquer, faults in the oxide layer, impurities in the material, etc., or on the nature of the foodstuffs, e.g. their moisture content, pH (acidity), and the presence or absence of inhibitors such as sugar and fats.—MA.

8.4 Group 4

8.4

Corrosion Control in the Lake Maracaibo Oil Fields. J. H. Zauner, Creole Petr. Corp. *World Oil,* **131,** No. 3; 229-230+ (1950) Aug.

The direct losses attributable to the corrosion of the Lake Maracaibo oil gathering system amount to more than $1 million annually. A description of the lake and gathering system, types of corrosion encountered and service records of equipment are given. The use of insulating flanges to reduce galvanic corrosion, various types of line coatings and methods of protecting marine craft are presented.

8.4, 5.3

Nickel Plated Tubing Is Being Used to Combat Corrosion. *Steel,* **127,** No. 9, 71 (1950) Aug. 28.

Nickel plated tubing is being used to combat corrosion in sour oil wells. Over 30,000 lineal feet of 2 to 2.5-in. tubing have been internally nickel plated for this purpose.

8.4.3, 7.2, 5.4.2

Concrete Coated Pipe for Swampy Terrain. A. Gibbon. *World Oil,* **131,** No. 6, 247+ (1950) Nov.

A method is described utilizing a combination of extrusion and ramming for applying a very dry mix of concrete to the outside of a vertically held joint of pipe. Any desired weight can be added to meet negative buoyancy requirements and the heavily coated pipe can be handled in the field with the same equipment and methods used for any precoated or plant coated pipe.

8.4.3, 6.4.2

Light Alloy in the Petroleum Industry. —V. —VI. *Light Metals,* **12,** No. 138, 372-381 (1949); No. 141, 548-550. Cf. *ibid.,* No. 137, 335. *Met. Abs.,* **17,** 990 (1949-1950).

V.—A discussion of the use of aluminum foil linings to storage tanks to prevent corrosion and the use of foil on the outside of tanks to reduce the internal temperature. Aluminum oil-storage tanks are described and the fire risk is assessed.

VI.—A description is given of applications of aluminum and its alloys in miscellaneous oil-field equipment. Drilling rigs, derricks and road tank lorries are described.—MA.

8.4.3

The Fight Against Corrosion. Part I. *Ind. Petrole,* **18,** No. 543, 545-547 (1950) Oct.

Physical properties of Ni-Resist, a special alloy used in the construction of pumps, distillation columns, etc. are listed and its excellent corrosion resistant properties and applications described. Interviews with various companies are included relative to their choice of alloy for various refinery applications. Of the unoxidizable metals available, ARCAP, a nonferrous alloy, is especially suited for petroleum treating units.

8.4.3, 7.10

Gaskets for the Oil Industry. H. H. Dunkle. Johns-Manville Sales Corp. Paper before ASME Petrol, Mech. Eng'g. Conf., New Orleans, La. *Oil Gas J.,* **49,** No. 22, 194+ (1950) Oct. 5.

The paper outlines the merits and limitations of compressed asbestos sheet-packing, corrugated metal and metal-jacketed asbestos, spirally wound metal asbestos, flat metal-jacketed asbestos and ring-type joint gaskets. It points out features of installation technique or closure design that may affect their performance. The majority of joints in oil industry installations are forged steel, raised-face flanges made to the A.S.A. standards for 150-300 pounds. For service at pressures above 500 psi or 500° F, the spirally wound gasket is made with stainless steel. Some refineries are changing from soft iron oval rings to stainless alloys for corrosive service. However, the A.P.I. specifies that the gasket be softer than the flanges which may be impossible to comply with in the stainless alloys. To obtain maximum corrosion resistance in a stainless-steel flange, it is generally necessary to heat treat the material to the dead soft condition and therefore, the flange will have the same hardness as the stainless-steel gasket.—INCO.

8.4.3, 5.8.2

Inhibitor in Stick Form Stops Corrosion in Louisiana Gas Well. G. M. Harper, Jr. *Petroleum Eng.,* **22,** B54+ (1950) Nov.

Presents caliper charts taken from tubing corrosion surveys of the above well, also characteristic caliper charts for tubing having no corrosion, mild corrosion, severe corrosion and very severe general corrosion. Test coupons and water condensate analyses were also used to determine the extent of corrosive conditions. Since severely corrosive conditions were indicated, proprietary organic stck inhibitors were tried. The second type — Tretolite Co.'s "Kontol 201"—gave excellent results as shown by continuation of the coupon tests and water analyses, and another caliper survey. —BLR.

8.5 Group 5

8.5, 5.4

Mill Painting and Its Relation to Mill Maintenance. O. F. Shobe, Glidden Co. Paper before Amer. Pulp & Paper Mill Supt's Assn. Ann. Mtg., Chicago, June 10, 1951. *Paper Trade J.,* **130,** No. 24, 102-104+ (1950) June 15.

To prevent corrosion of iron and steel in pulp and paper mills by chlorine gas, sulfur dioxide, calcium and sodium salts, alkaline solutions and moisture, paints have been developed which have chemical resistant properties. The first important step is the properly prepared surface to ensure proper paint adhesion. Tests show there is no paint that will stop the spread of rust, so the surface must be scraped clean. Sandblasting or flame-cleaning will remove steel corrosion products and mill scale prior to priming and finishing. Primers protect steel against mechanical and electrolytic action. A vinyl metal conditioning primer and vinyl finishing enamels give excellent protection. If a complete vinyl system is not possible, a vinyl primer should be used. If it is impossible to remove all the rust, a primer with 20-30 percent linseed or sardine oil should be used. Synthetic rubber emulsion paint is best for pulp mills since it is resistant to moisture and chemical penetration. Gloss phenolic or alykd enamels are used for trim coatings in all but the worst parts of the mill. They can be used over synthetic rubber emulsion paints as a sealer. —INCO.

8.5

Corrosion Problems in Sulphate Pulp Mills. C. G. Von Essen. Tech. Assoc. Pulp Paper Ind., **33,** No. 7, 14A+ (1950) July.

After investigation, it was found that corrosion in the liquor systems of sulfate pulp mills depends mainly on the formation of iron sulfide. The reason for differences in corrosion is in the method of digestion. The sulfide content, temperature and speed of liquor are the most important influences. Stainless steel (13.3 chromium) tubes improve heat transfer in evaporators. To reduce corrosion in diffusers, linings of concrete (1 part cement, 2 parts sand) were used. The addition of 5 nickel in digesters resulted in higher corrosion resistance but impaired the welding properties. The use of stainless steel equipment greatly eliminated corrosion. However, the price of 13.5 chromium and 18-8 is high in comparison with nickel alloys and carbon steel. Existing plate materials can be protected by the help of galvanic cur-

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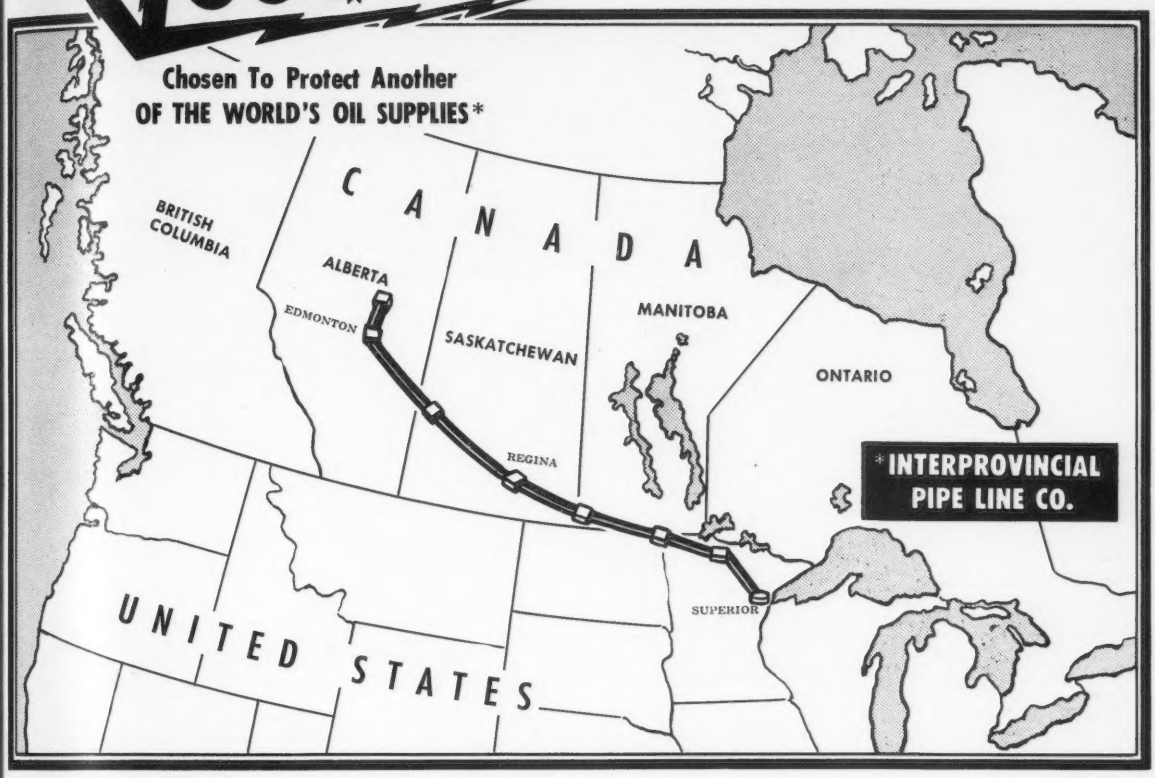

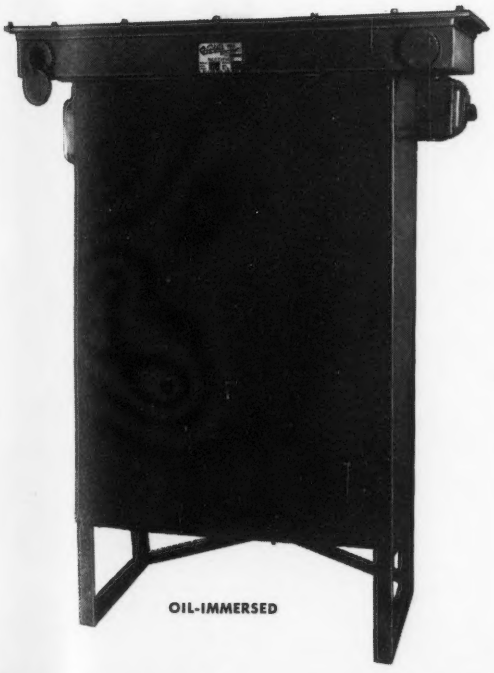

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rents or connection of direct current. The amount of silicic acid and other inhibitors in the liquors is important. On most exposed areas, this protection is best obtained by the insertion of sheets or tubes of stainless material or by spray coating with similar materials. Laboratory experiments and graphs of results and table of corrosion tests on various nickel, chromium and stainless steels are given.—INCO.

8.5

Corrosion Problems in Swedish Sulphate Pulp Mills. (In Swedish.) C. G. Von Essen. *Svensk Papperstidn,* **52,** 549-559 (1949). *Paper Ind.,* **32,** No. 1, 86 (1950) Apr.

Experiments were made with different types of steel for digesters, evaporators and electrofilters in the Swedish sulfate pulp mills. The presence of silicon in steel decreased its resistance to white, green and black liquors, while 1-2 nickel or cobalt caused a noticeable improvement in resistance to corrosion. The joint application of ordinary and stainless steels offered protection to steel and decreased the corrosiveness of sulfate liquors, provided the latter contained small amounts of silicic acid or other anodic inhibitors. The corrosive effects of black liquors were reduced by oxidation according to the method of Bergstrom and Trobeck. Black liquors from different mills shows great variations in corrosiveness even if their solid contents are similar.—INCO.

8.5, 5.1

The Corrosion of Ferrous Metals. W. Westwood and R. I. Higgins. Reprint of paper from *Proc. Tech. Sec., Paper Makers' Assoc., G. Brit. & Ireland,* **29,** Pt. II, 267-301; disc. 283-301 (1948). BCIRA External Rept., 297.

General introductory notes on nature of corrosion of ferrous materials, discussion of two main sets of circumstances in which ferrous metals are exposed to corrosive influences (atmosphere, liquids), factors affecting corrosion in liquid media, effects of corrosion, with open reference to cast iron; and methods of protection against corrosion (brief reference to potential value of nodular cast iron in resisting cavitation erosion, and to Ni-Resist, Ni-Hard, changes in environment, use of inhibitors, cathodic protection are given). Practical examples are given of corrosion, cavitation-erosion and related forms of attack with special ferefence to their occurrence in paper-mill plant (including photographs of Monel impeller from pump handling concentrated alum, which suffered cavitation-erosion). Much of the discussion related to materials for use in M.G. cylinders.—INCO.

8.5.2

Problem of the Quality of Tank Blocks for the Glass Industry. (In Polish.) F. Nadachowski. *Prace Badawcze Glownego Instytutu Metalurgii i Odlewnictwa,* **2,** No. 3, 169-185 (1950).

Factors influencing the deterioration of refractory materials by molten glass are discussed. Reviews test methods for tank blocks. The method used by the author consisted of treating small specimens with molten soda at 1000° C. On the basis of this method, several Polish clays were tested to determine their suitability for tank-block production. Results of tests of tank blocks made in Poland and elsewhere are presented and compared.—BLR.

8.5.3, 5.4.7

Maintenance Painting Specifications for Paper Mills. L. S. Oyster. *Paper Trade J.,* **131,** No. 8, 16+ (1950) Aug. 24.

The first part reveals interesting facts concerning the cause of paint failures and the types of paint. The second part gives painting specifications for filter plant, saw mill and wood room, boiler house, hydroelectric plant, turbine and generator rooms, in ground wood, sulfite and sulfate, mills and rag mills where applicable.—INCO.

8.5.3

Corrosion in a Neutral Semi-Chemical Pulp Mill. L. W. Murtfeldt. Consolidated Water Power & Paper Co. *Paper Trade J.,* **131,** No. 12, 23-24 (1950) Sept. 21.

The article discusses the equipment in the liquor, cooking and refining plants and evaporators. Iron pumps and steel used for pipe, target plates, shafts, beams and plow blades are subject to corrosion. Pumps of Ni-Resist material and steel parts replaced by chromium-nickel steels have proven to be corrosion resistant. Stainless steel is used for shafts, beams, plow blades and buckets. The chromium-nickel steels, however, are found to be too expensive.—INCO.

8.5.3, 6.3.8, 4.3.2

The Use of Lead in the Pulp and Paper Industry. V. P. Edwardes. *Paper Trade J.,* **131,** No. 17, 18-19, 22-23 (1950) Oct. 26.

Discussion on the use of lead in sulfite acid manufacture, acid pulping, bleaching and stock handling in the pulp and paper industry. Lead is satisfactory for handling sulfite acid at normal temperatures and pressures and is superior to sulfur dioxide carrying traces of sulfuric acid. It is used to advantage in chemical pulp and ground-wood bleach plants where the zinc hydrosulphite process is used. For stock preparation and handling wherever alum is used, lead has found extensive application. It is employed for its corrosion resistance to bisulphite and free sulfurous acid combinations, sulfuric acid and alum. It has proven to be one of the easiest materials to keep clean, it gives long service and it can be repaired in place. Tellurium and antimonial lead is used for cooler piping. Illustrations.—INCO.

8.8 Group 8

8.8.1, 7.3.5

Instrumentation in a Modern Chlorine Handling Plant. J. M. Hildyard. Hooker Electrochem. Co. Paper before Electrochem. Soc., Cleveland, Apr. 19-22, 1950. *J. Electrochem. Soc.,* **97,** No. 11, 367-376 (1950) Nov.

The control equipment for a modern chlorine handling plant is described and analyzed. The process consists of equipment for collecting, cooling, drying, compressing and liquefying chlorine gas. Personal supervision of the equipment by the operators was reduced by the control means employed. Some information is given for the selection and installation of instruments for chlorine plants. If the chlorine is absolutely dry and the lines are dry, valves with cast iron bodies and stainless trim, except for stems are acceptable. Stainless steel stems are not permissible in sliding stem valves but are acceptable on rotary stem valves. The stems of sliding stem valves should be of Hastelloy C. Some of the crevices in the valves do not dry out and when the line is used again, valve trouble nearly always develops. The most satisfactory solution is to use Hastelloy carbon trim throughout. Valves in lines that are subjected to frequent streaming should have stainless steel bodies to resist the corrosive action of ferric chloride which forms when the line is returned to use.—INCO.

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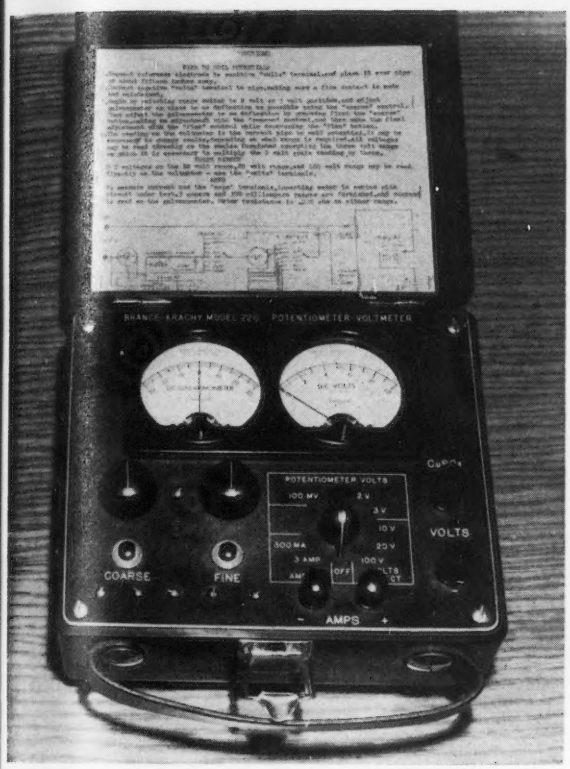

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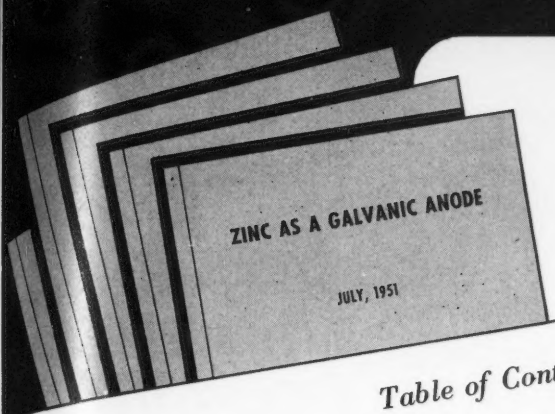

For your reference and use...

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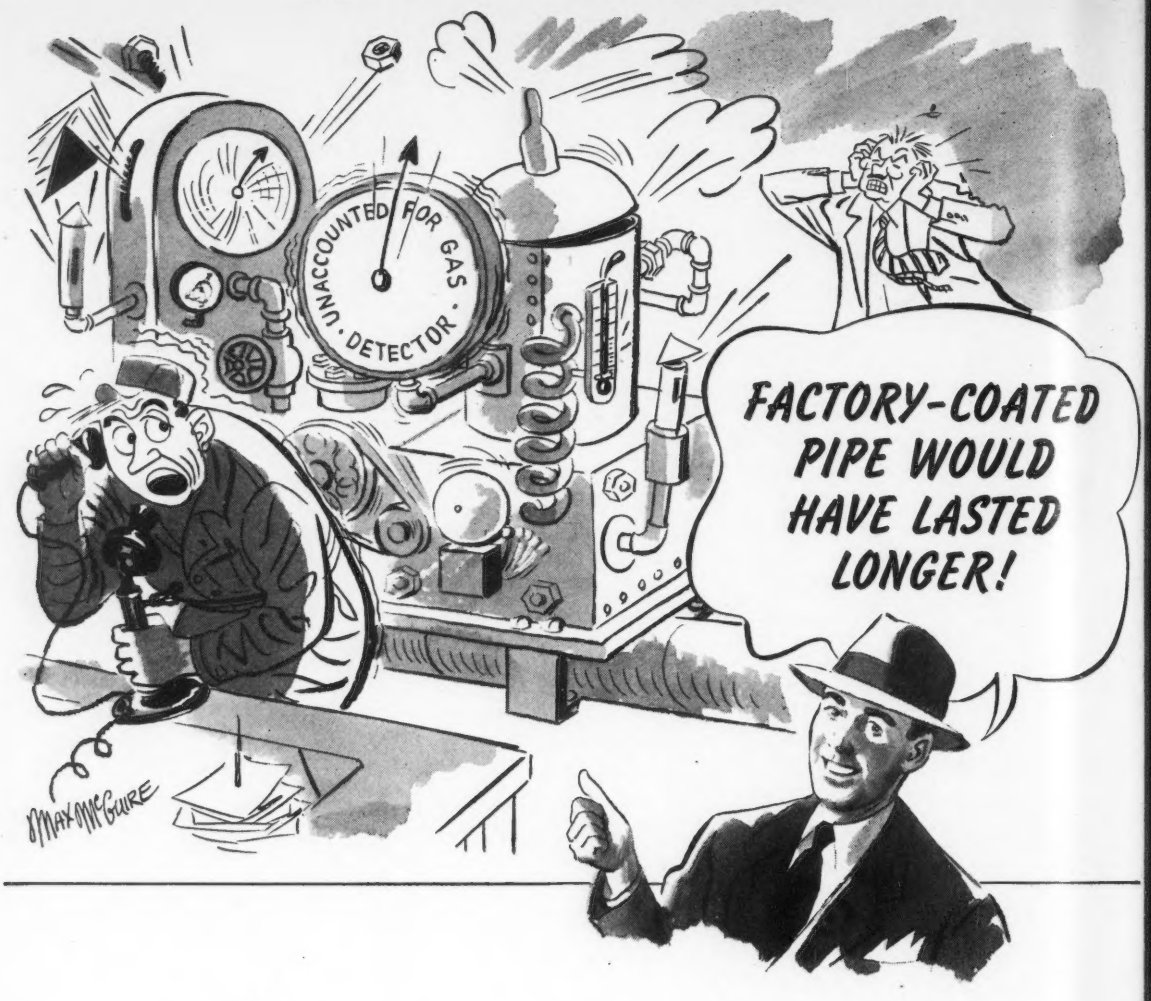

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MEMBERSHIP DIRECTORY

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Articles of Organization
and
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NATIONAL ASSOCIATION
of
CORROSION ENGINEERS

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USE OF THE MEMBERSHIP DIRECTORY

The membership list published herein is intended for use in connection with the activities of the Association. Its use for circulation purposes not directly connected with those activities is not approved. Members are requested to assist officers in discouraging the use of this list for any unauthorized purpose.

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- Metropolitan New York
- Philadelphia
- Pittsburgh
- Western New York

2. North Central Region

Sections:

- Chicago
- Cleveland
- Detroit
- Eastern Wisconsin
- Greater St. Louis
- Southwestern Ohio

3. South East Region

4. South Central Region

Sections:

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- Corpus Christi
- Houston
- New Orleans-Baton Rouge
- North Texas
- Permian Basin
- Sabine-Neches
- Shreveport
- Teche
- Tulsa
- University of Houston-Junior

4. Western Region

Sections:

- Los Angeles
- Salt Lake
- San Francisco Bay Area

Alphabetical Listing of Members

†Indicates a Corporate Member Representative. The company affiliation may be found by consulting the listing of Corporate Members beginning on page 37.

*Indicates a Junior Member.

A

†Abbot, Charles B. ..... Colorado Springs, Colo.
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†Abernathy, M. A. ..... Shreveport, La.
Abraham, Mack ..... Lake Charles, La.
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Adams, Lee A. ..... Westwego, La.
Adams, Robert H. ..... Houston, Tex.
Adamson, N. E. ..... Portsmouth, Va.
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Armstrong, Bob J. ..... Houston, Tex.
Armstrong, Clifford B., Jr. ..... Wyandotte, Mich.
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B

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Ball, James F. ..... Tulsa, Okla.
Ball, Norman D. ..... Shreveport, La.
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Bird, J. Dwight ..... Boston, Mass.
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Brown, H. D. Tulsa, Okla.
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Brown, Harry F. New Haven, Conn.
Brown, John R. Inglewood, Calif.
Brown, Kenneth W. San Francisco, Calif.
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Butler, Edmund R. Chattanooga, Tenn.
Butler, George D. Corpus Christi, Tex.
Butterbaugh, H. W. Kenosha, Wis.
Byarre, William W. Philadelphia, Pa.
Byer, George T. Lafayette, La.

C

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†Caldwell, Marion D. Wilmington, Dela.
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Callahan, V. L. Winter Park, Fla.
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Camp, E. Q. Baytown, Tex.
Campbell, A. B. Houston, Tex.
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Carson, John H. Cleveland, Ohio
Carter, Anthony J. Newark, Ohio
Carter, George M., Jr. Minneapolis, Minn.
Carter, John Jacksonville, Fla.
Carter, Nelson B. Rochester, N. Y.
Casanova, Otis B. Rolling Fork, Miss.
Case, L. C. Tulsa, Okla.
Case, William W. Springfield, Mass.
†Casey, J. Pat, Jr. Chicago, Ill.
Caster, Arthur D. Cincinnati, Ohio
Castle, Harry, Jr. Amarillo, Tex.
Cates, Walter H. Los Angeles, Calif.
Cathcart, Wallace P. Pittsburgh, Pa.
Catts, Gordon R. Corpus Christi, Tex.
Cavanagh, W. R. Detroit, Mich.
Cayford, James M. Cleveland, Ohio
†Ceccon, J. B. Chauncey, N. Y.
Chadwick, David H. Anniston, Ala.
Chadwick, R. H. Salt Lake City, Utah
Chalmers, William H. Rawalpindi, West Punjab, Pakistan
Chamberlain, Frank H., Jr. Charlotte, N. C.
Chambers, Alexander R., Jr. Pittsburgh, Pa.
†Chandler, John W. Buffalo, N. Y.
Chaney, L. P. Houston, Tex.
†Chapman, E. E. Chicago, Ill.
Chapman, O. Charles Nichols, Fla.
Chapman, Walter H. Phoenix, Ariz.
Charat, Hanoh Dallas, Tex.
Charter, Kenneth F. Milwaukee, Wis.
Chartrand, V. Edward Dallas, Tex.
Chatelain, John B. Freeport, Tex.
Chatenever, Alfred Norman, Okla.
Chenoweth, William F. Dayton, Ohio
Cherry, R. Texas City, Tex.
Chesney, Robert B. Benton, La.
Chesnutt, N. P. Dallas, Tex.
Chiasson, Crawford E. West Lake, La.
Childs, Benjamin F. Washington, D. C.
Chisholm, Charles G. Kokomo, Ind.
Christ, George J. Brooklyn, N. Y.
Christ, Robert E. Pittsburgh, Pa.
Chronister, James L. Scott, La.
Chuck, Frank Cabimas, Estado Zulia, Venezuela, South America
Church, Laurence T. Springfield, Ill.
Ciborski, John M. Brooklyn, N. Y.
Cibula, Henry J. Pittsburgh, Pa.
Claiborne, Tom A. Cleveland, Ohio
Clancy, J. J. Deerfield, Ill.
Clark, Claude L. Canton, Ohio
Clark, Hezzie Houston, Tex.
†Clark, Joseph B. Tulsa, Okla.
Clark, Manley H. Newport Beach, Calif.
†Clark, O. W. Birmingham, Ala.
Clark, Peter Durham, England
Clarke, B. C. Los Angeles, Calif.
Clarke, Richard P. Port Arthur, Tex.
Clarvoe, George W. Manville, N. J.
Clausen, C. C. Dixon, Ill.
†Clay, J. A., Jr. Fort Worth, Tex.
Clayton, Henry M. Memphis, Tenn.
Clayton, William J. Detroit, Mich.
Clement, Albert J. New York, N. Y.
Clermont, William L. Newark, N. J.
Clifford, Hugh J. Lockport, N. Y.
Clifton, W. M. Amarillo, Tex.
Cloninger, Fred M. Tulsa, Okla.
†Clothier, A. T. Tulsa, Okla.
†Cloud, C. E. Tulsa, Okla.
Cloyes, William P. Henderson, Nev.
Coates, Proctor G. Detroit, Mich.
Coats, Sanford C. Oklahoma City, Okla.
Cobb, Stephen P. Ashville, N. C.
Cobbett, C. D. New Kensington, Pa.
Coberly, Camden A. Webster Groves, Mo.
Cochran, William C. New Kensington, Pa.
Cocke, William J. Albuquerque, N. M.
†Coen, I. H. East Pittsburgh, Pa.
Coffer, Harold R. Donaldsonville, La.
Coghill, H. T. Chicago, Ill.
Cohen, Benjamin J. Jersey City, N. J.
Cohen, Ralph Nutley, N. J.
Colburn, Lyle W. Midland, Mich.
Cole, Frank H. New York, N. Y.
Cole, Ralph R. Dallas, Tex.
Cole, Robert M. Fort Worth, Tex.
Coleman, O. K. Lafayette, Ind.
Coleman, W. B. Philadelphia, Pa.
Coleman, W. D. Springfield, Mo.
Coley, Glenn Detroit, Mich.
Collins, Dean D. Shreveport, La.
Collins, Harry S. Long Island City, N. Y.
Collins, James H. New York, N. Y.
Collins, J. L. Angleton, Tex.
Collins, John W. Beaumont, Tex.
Collins, Walter F. New York, N. Y.
Collins, William J. Corning, N. Y.
Collopy, Joseph P. Cody, Wyo.
Collora, Nicholas A. Terre Haute, Ind.
Colyer, David J., Jr. Beverly Hills, Calif.
Comeaux, Roy V. Baytown, Tex.
Compton, Kenneth G. Murray Hill, N. J.
Compton, Maryann Cincinnati, Ohio
Conde, Luis Lopez Caracas, Venezuela
Condry, James T. Tulsa, Okla.
†Connell, Jasper S. Wilmington, Calif.
Connelly, D. J. Cleveland, Ohio
Connelly, Lewis D. St. Louis, Mo.
Connon, William D. Philadelphia, Pa.
Connors, William F. Houston, Tex.
Conrad, Howard P. Port Huron, Mich.
Conroy, John H. Houston, Tex.
†Converse, E. M. Chicago, Ill.
Conviser, M. B. Kingsport, Tenn.
Cook, George S. Scotia, N. Y.
Cook, Lawrence S. Allenport, Pa.
Cook, Leon D., Jr. Wyandotte, Mich.
Cook, William B. Port Arthur, Tex.
Coolbaugh, William E. Peru, Ill.
Cooley, Herbert M. Tulsa, Okla.
Coons, Ansel L. San Antonio, Tex.
Cooper, Wm. C. Cudahy, Wis.
Copeland, Raymond D. Glenwillard, Pa.
Copley, James S. Cleveland, Ohio
Coppersmith, Charles R. Chicago, Ill.
Copson, Harry R. Cranford, N. J.
Corcuera, Francisco L. Tampico, Mexico
†Cordell, P. M. Fort Worth, Tex.
Corfield, Guy Los Angeles, Calif.
Cornett, W. J. Galena Park, Tex.
Costanzo, Frank F. Pittsburgh, Pa.
Costello, Carl C. Llanerch, Pa.
Cotton, William J. Milwaukee, Wis.
†Coulson, H. M. Tulsa, Okla.
Coulter, Elmer N. Lake Charles, La.
Coursey, Ralph W. Oklahoma City, Okla.
†Court, W. F. New York, N. Y.
Couy, C. J. McKeesport, Pa.
†Cowart, B. C. New York, N. Y.
Cowles, James R. Tulsa, Okla.
Cox, Edwin S. Pittsburgh, Pa.
Cox, Gaylord H. Lake Charles, La.
Cox, George C. Charleston, W. Va.
Cox, Gilbert L. Rochester, N. Y.
†Cox, John W. Salt Lake City, Utah
Cox, Milton K. Pittsburgh, Pa.
†Coyle, T. G. New York, N. Y.
Craig, James H. New Orleans, La.
Craig, J. Russell Bethlehem, Pa.
†Cramer, Anthony H. Detroit, Mich.
Crane, Harold E., Jr. Pittsburgh, Pa.
Crane, James Cincinnati, Ohio
Craver, Albert F. Cleveland, Ohio
Crawford, Guy G. Fort Worth, Tex.
Creevy, Joseph A. Newport, Ky.
Crobaugh, Albert O. Caldwell, N. J.
†Crockett, C. L. Roanoke, Va.
Croney, Samuel I. Philadelphia, Pa.
Crosby, William L. New York, N. Y.
Crossman, R. Nathan, Jr. Houston, Tex.
Crowe, Raymond H. Houston, Tex.
Crowley, Edward J. New York, N. Y.
Crumback, A. Lloyd Edmonton, Alberta, Canada
†Cucullu, Lionel J. New Orleans, La.
Culbertson, Alan F. Chicago, Ill.
Culbertson, J. L. Tulsa, Okla.
Cullen, Thomas G. Orinda, Calif.
Cummer, William F. Beeville, Tex.
Cummins, Frank M. St. Louis, Mo.
Cunningham, George S. Hartford, Conn.
Curdts, E. B. Philadelphia, Pa.
Curley, William R. Clarksburg, W. Va.
Curran, James J. Greensburg, Pa.
Curran, Michael Tulsa, Okla.
†Current, F. L. Oil City, Pa.
Curry, Charles H., Jr. Boston, Mass.
Curtis, Robert W. Alliance, Ohio
Cushing, Daniel Boston, Mass.
Cushman, George A. Brenham, Tex.
Cutting, Merritt E. South Barre, Mass.

D

Daino, Pietro Naples, Italy
Dale, Dudley R. Toledo, Ohio

Dale, Lawrence H. Berwick, Pa.
Dalrymple, Robert S. Richland, Wash.
Daly, George Luke Shreveport, La.
Daniels, Fred A., Jr. Des Moines, Iowa
Daniels, Leonard J., Jr. Fort Worth, Tex.
Danne, Herbert J. Tulsa, Okla.
†Danser, John W. New York, N. Y.
Dantz, Thomas M. New York, N. Y.
Darin, Edward J. Falls Church, Va.
Darling, P. E. Texas City, Tex.
Darrin, Marc Baltimore, Md.
Daub, Walter H., Jr. Pittsburgh, Pa.
Daugherty, James G. Philadelphia, Pa.
Davenport, John A. Cincinnati, Ohio
Davie, Frank E. Los Angeles, Calif.
Davies, Alan T. Melbourne, Victoria, Australia
†Davis, Carl R. Butte, Mont.
Davis, Charles T., Jr. Houston, Tex.
Davis, Edwin G. Haddonfield, N. J.
Davis, F. W. Washington, D. C.
Davis, Jack G. Houston, Tex.
Davis, James A. Fort Worth, Tex.
Davis, J. E. Fort Worth, Tex.
Davis, Leon B. Washington, D. C.
Davis, Leroy J. Glencoe, Ill.
Davis, L. W. Cleveland, Ohio
Davis, Robert A. Birmingham, Ala.
Davis, Russell L. New York, N. Y.
Daw, Ronald F. New York, N. Y.
Dawson, R. A. J. Houston, Tex.
Day, Clyde W. Bishop, Tex.
†Day, Kenneth A. Denver, Colo.
Day, Stephen D. Houston, Tex.
Daymude, John F. Cincinnati, Ohio
†Deacon, William T., III St. Louis, Mo.
Deaconson, James N. Wilmington, Del.
Dean, John E. Kingsville, Tex.
Dean, Lyle E. Walnut Creek, Calif.
Dean, Roy O. Emeryville, Calif.
DeBeers, Franklin M. Glenview, Ill.
Debevoise, George D. Brooklyn, N. Y.
Debord, George E. Pittsburgh, Pa.
DeBruyn, Lobry Delft, Netherlands
Decowsky, George N. Philadelphia, Pa.
Deering, F. A. Arkansas City, Kans.
Deering, Robert G. Beaumont, Tex.
De Gaw, Boyce Houston, Tex.
Degnan, Thomas F. Penns Grove, N. J.
De Groot, John W. Harrisburg, Pa.
Dehaan, Peter C. Des Moines, Iowa
†Deichler, J. K. Philadelphia, Pa.
De Laski, Robert D. New York, N. Y.
DeLong, Raleigh, Jr. Texas City, Tex.
De Long, William B. Wilmington, Del.
†De Mey, C. F. New York, N. Y.
De Minjer, Clara Henderina Eindhoven, Netherlands
Denison, Irving A. Washington, D. C.
Dennis, Sidney St. Louis, Mo.
Denoon, E. M. Miami, Fla.
Depaul, D. J. Pittsburgh, Pa.
Deringer, Wayne A. Milwaukee, Wis.
Detrick, Charles N. Cleveland, Ohio
Deuber, Carl G. Ardsley, N. Y.
Devoluy, Raymond New York, N. Y.
De Waltoff, Lionel New York, N. Y.
†Dewar, J. S. Bartlesville, Okla.
Dewar, William Philadelphia, Pa.
Dey, Charles L. Pittsburgh, Pa.
Dial, Daniel F., Jr. Houston, Tex.
Diamond, Horace W. Chicago, Ill.
Dick, Howard C. Westwego, La.
Dickinson, L. R. Plainfield, N. J.
Dickinson, Willis F. Los Angeles, Calif.
Dierk, Herbert W. Mineola, N. Y.
Dierks, A. Norman Philadelphia, Pa.
Diehlman, George New York, N. Y.
†Diemer, R. B. Los Angeles, Calif.
Dietz, Clifton E. Beeville, Tex.
Dietze, Irwin Charles Los Angeles, Calif.
Digrina, Earl R. New Kensington, Pa.
Dillon, Charles P. Texas City, Tex.
Dirks, Richard W. Tuleta, Tex.
Disanto, Bartel J. Salt Lake City, Utah
Dittbrenner, Raymond A. New York, N. Y.
Dittman, William E. Los Angeles, Calif.
Dix, E. H., Jr. New Kensington, Pa.
Dixon, Joseph L. Houston, Tex.
Dod, A. Bayard, Jr. Los Angeles, Calif.
Dodgen, James E. Silver Springs, Md.
Doelling, George L. St. Louis, Mo.
Dolson, Frank E., Jr. University City, Mo.
Donati, Enrico Dalmine, Bergamo, Italy
*Donnellon, John B. Mt. Vernon, N. Y.
Donnelly, Joseph B. Philadelphia, Pa.
Donnelly, Lt. Patrick R. Oceanside, Calif.
Donoho, Charles K. Birmingham, Ala.
Donohoe, J. L. Newark, N. J.
†Donovan, L. B. New York, N. Y.
Donovan, W. H., Jr. Birmingham, Ala.
Doremus, E. P. Houston, Tex.
Doremus, Gordon L. Houston, Tex.
Dorr, Frank I. Houston, Tex.
Dorsey, Joseph S. Los Angeles, Calif.
Doss, Glenn K. Longview, Tex.
Dotson, James B. Oakland, Calif.
†Dougherty, William J. Sioux City, Iowa
Doughty, S. E. Union, N. J.
Douglass, Dwight Hartford, Conn.
†Douglass, E. W. Carlsbad, N. M.
Douglass, Harry E. Los Angeles, Calif.
Dowe, Robert J. New Orleans, La.
Dowling, Roy C. Appleton, Wis.
Downing, W. E. Pittsburgh, Pa.
Dragics, Earl V. Houston, Tex.
Dragoset, William H. Colonia, N. J.
Dravnieks, Andrew Chicago, Ill.
†Drewelow, Earl Joplin, Mo.
Dreyman, Edgar W. Brooklyn, N. Y.
Dubois, Carlton H. Buffalo, N. Y.
Duce, R. E. Webster Groves, Mo.
Duffner, Gordon H. Chicago, Ill.
Dugan, James A. Cambridge, Mass.
Duggan, Maryann Dallas, Tex.
Duim, Albert R. Los Angeles, Calif.
Dulaney, Robert Philadelphia, Pa.
Dunagan, George M. Salem, Ill.
Dunasky, C. F. Cleveland, Ohio
Dunham, R. A. Long Beach, Calif.
Dunn, E. F. Buffalo, N. Y.
Dunn, James W. Detroit, Mich.
Dunning, Sheldon Seattle, Wash.
Duree, Jack T. Fort Worth, Tex.
Durishin, John F. Allentown, Pa.
Durman, Frederick P. Muncie, Ind.
Durning, A. W. New Orleans, La.
Dutton, W. L. Chatham, Ontario, Canada
Dwyer, James T. Port Arthur, Tex.
Dwyer, John D., Jr. Wakefield, Mass.
†Dwyer, T. J. Baltimore, Md.
Dyble, Edward Cleveland, Ohio
Dykman, Milton Rochester, N. Y.

E

Eagan, T. E. Grove City, Pa.
Eager, Russell G. Pavilion, N. Y.
Earl, Robert, Jr. Utica, N. Y.
Earnshaw, Charles S. Oakland, Calif.
Easson, William H. Chicago, Ill.
Ebbs, Edward L. Houston, Tex.
Eberhardt, Ernest T. Hackensack, N. J.
Eberhardt, T. J. Hackensack, N. J.
Eberl, James J. Chester, Pa.
†Eberle, F. Alliance, Ohio
Ebersole, Larue K. Colorado Springs, Colo.
Ebert, Raymond E. Brentwood, Mo.
†Eckles, W. W. Beaumont, Tex.
Eckmann, Clarence W. Wyandotte, Mich.
Eddison, Clifford Camden, N. J.
Eddy, Levi C. Hinsdale, Ill.
Edgar, Lenville C. Houston, Tex.
Edminster, James W. Pampa, Tex.
Edmonson, A. Glen Jacksonville, Fla.
Edwards, Marvin J. San Diego, Calif.
Edwards, Robert W. Emeryville, Calif.
Edwards, W. H. Houston, Tex.
Effinger, R. T. Martinez, Calif.
Efron, Aaron St. Paul, Minn.
†Egly, Richard S. Terre Haute, Ind.
Eickhoff, Arnold J. Brooklyn, N. Y.
Eilerts, C. Kenneth Bartlesville, Okla.
Eisenmann, Charles Edward New Brunswick, N. J.
Elder, John W. Tulsa, Okla.
Elder, Lowell L. Columbus, Ohio
Eldred, Norman O. Vicksburg, Mich.
Eldredge, George Emeryville, Calif.
Elkins, Randell L. Midland, Tex.
†Ellerbrake, Earl G. Cleveland, Ohio
Elliott, Jack H. Los Angeles, Calif.
†Elliott, Robert D. Dallas, Tex.
Elliott, William E. Milwaukee, Wis.
Ellis, Murray P. Painesville, Ohio
Ellis, O. B. Middletown, Ohio
Ellis, William Jackson Oakland, Calif.
Elliston, H. H. Tulsa, Okla.
Ellwood, Edward E. St. Louis, Mo.
Elsener, L. A. San Francisco, Calif.
Emerson, Richard J. El Paso, Tex.
Emery, D. T. John Brownsville, Tex.
Emery, Maurice N. Corpus Chrisiti, Tex.
Enders, Roger S. Long Beach, Calif.
Endicott, L. A. Texas City, Tex.
Englehart, Edwin T., Jr. New Kensington, Pa.
English, E. Rowland Elizabeth, N. J.
English, Gyme C. New Kensington, Pa.
English, James L. Oak Ridge, Tenn.
Ennis, Herbert E. New York, N. Y.
Enquist, Melvin A. Alhambra, Calif.
Eplett, Albert D. Stratford, Conn.
*Epstein, Leonard North Arlington, N. J.
Erath, Charles A. San Francisco, Calif.
Erganian, Alex M. Atlanta, Ga.
Ergul, Necdet F. Mineola, N. Y.
Erickson, Bert E. Salt Lake City, Utah
†Erickson, C. A., Jr. Pittsburgh, Pa.
Erickson, E. T. Chicago, Ill.
Ericson, Rudolph C. Hammond, Ind.
Ernst, Jacob W. Milwaukee, Wis.
Eubanks, Erdie B., Jr. Los Angeles, Calif.
Evans, C. W. Shreveport, La.
Evans, Charles T., Jr. Delmont, Pa.
Evans, Clair O. New York, N. Y.
Evans, David H. Toronto, Ontario, Canada
Evans, Dwight J. Tulsa, Okla.
Evans, Herbert V., Jr. Pittsburgh, Pa.
Evans, Herschel Topeka, Kan.
†Evans, J. M. San Francisco, Calif.
Evans, Robert L., Jr. Houston, Tex.
†Evans, Rulison Wilkes-Barre, Pa.
Evans, Thomas C. Orange, Tex.
Everest, Guy N. Passaic, N. J.
Everett, Albert S. San Francisco, Calif.
Everett, Ralph H. New York, N. Y.
Everhart, E. Wayne Spokane, Wash.
†Eves, W. D. Heath New York, N. Y.
Ewing, James H. Long Island City, N. Y.
†Ewing, L. W. Chicago, Ill.
Ewing, Scott P. Tulsa, Okla.
Exum, James P., Jr. Beaumont, Tex.

F

†Fair, W. F., Jr. Westfield, N. J.
Falck, Sylvan B. Cincinnati, Ohio
Fanett, H. M. Houston, Tex.
†Farber, J. D. Philadelphia, Pa.
Farkas, Ernest Charles Euclid, Ohio
Farkas, Howard New York, N. Y.
Farley, Elden R. Houston, Tex.
Farmer, C. E. Shreveport, La.
*Farmer, Sidney C., Jr. Galveston, Tex.
Farrar, Walter B. Kensington, Md.
Farwell, Milo S. San Francisco, Calif.
Fasig, Paul L. Woodbury, N. J.
Fasold, G. Arthur Cincinnati, Ohio
Featherly, Robert L. Saginaw, Mich.
Feldman, Karl T. Independence, Kan.
Feldstein, Henry H. Cleveland, Ohio
Feller, Eugene W. F. Pittsburgh, Pa.
Fellows, Claire H. Detroit, Mich.
†Fenn, George P. Peoria, Ill.
Fennel, Lawrence, Jr. Portland, Me.
Fenner, Otto H. St. Louis, Mo.
Fenton, J. Harry South Pasadena, Calif.
Fergusson, Robert A. Evanston, Ill.
Fernandez, Henry J. Texas City, Tex.
Ferraro, Anthony Woodhaven, N. Y.
Ferree, Ray J. St. Louis, Mo.
Ferrell, William Edward, Jr. Charlotte, N. C.
Fetner, Charles J., Jr. Vandergrift, Pa.
†Fetters, Karl L. Youngstown, Ohio
Few, William Cleveland, Ohio
Fiedelman, Howard W. Manistee, Mich.
Filkins, Harry L. Kansas City, Mo.
Fincher, D. R. Palestine, Tex.
Fincher, Robert K. Memphis, Tenn.
Fink, Frederick W. Columbus, Ohio
Finlay, Daniel F. Melvindale, Mich.
Firth, R. Smedley New York, N. Y.
Fischer, H. E. Houston, Tex.
Fisher, A. Orman Boston, Mass.
Fisher, B. M. Freeport, Tex.
Fisher, Earl E. Glen Olden, Pa.
Fisher, George A., Jr. St. Louis, Mo.
Fisher, John R., Jr. Dayton, Ohio
Fisher, Max C. Fort Worth, Tex.
Fisher, Ralph A. Houston, Tex.
Fiske, C. Walter, Jr. Louisville, Ky.
Fithian, John W. Philadelphia, Pa.
Fitzgerald, J. Wilfrid Cleveland, Ohio
Fitzpatrick, Allyn H. Kansas City, Mo.
†Flanagan, J. C. Houston, Tex.
Flanders, Albert C. Benwood, W. Va.
Fleming, M. C. Bartlesville, Okla.
Fleming, Thomas J. Santa Monica, Calif.
Fleming, Tom L. Kansas City, Mo.
Flentje, Martin E. Philadelphia, Pa.
Fletcher, Mark D. Chicago, Ill.
Flickinger, L. C. Youngstown, Ohio
Flint, J. W. Wichita, Kan.
Flocke, Frank G. Cleveland, Ohio
Flood, Earl F. Hudson, Ohio
Flor, Loy L. El Cajon, Calif.
Flores, Leopoldo Nettel Tampico, Tamps., Mexico
†Flournoy, R. W. Argo, Ill.
Flynn, C. K. Sarnia, Ontario, Canada
†Flynn, E. D. Oakland, Calif.
Foelsch, Henry W. Chicago, Ill.
Fogelquist, Harold T. Rome, Italy
Fontana, M. G. Columbus, Ohio
Footner, H. B. London, England
†Forbes, A. L., Jr. Houston, Tex.
Forbes, M. C. Houston, Tex.
Ford, Charles D. Monrovia, Calif.
Forderbrugen, Kevin J. St. Peter, Minn.
Forsha, William D. Pampa, Tex.
Fort, George A. Gary, Ind.
Fossett, William K. Wichita, Kan.
Foster, Albert C. New York, N. Y.
†Foster, J. L. Dallas, Tex.
Fouraker, Robert W. Wilmington, Calif.
Fowler, Edward F. Aurora, Ill.
Fox, Arthur R. Oakland, Calif.
Fox, R. W. Newtown Square, Pa.
Francis, Howard T. Chicago, Ill.
*Franek, John A. Cincinnati, Ohio
Frank, Marion E. Houston, Tex.
Frankos, Michael T. Dhahran, Saudi Arabia
Frasch, H. H. Dallas, Tex.
Fraser, John P. Walnut Creek, Calif.
Fredenburg, Charles W. Chicago, Ill.
Frederickson, Hubert M. Minneapolis, Minn.
Fredley, Kenneth C. Pittsburgh, Pa.
Freeman, C. E. Oakland, Calif.
†Freeman, John R., Jr. Waterbury, Conn.
Freeman, Richard S. Lake Charles, La.
Freeman, William R. Philadelphia, Pa.

French, John D. ..... Toronto, Ontario, Canada
French, John W. ..... Borger, Tex.
Freynik, Henry S. ..... Riverside, N. J.
Friant, Stewart ..... Baltimore, Md.
Frieden, Alexander ..... Milwaukee, Wis.
Friedl, Burt ..... Columbus, Ohio
Friedman, Charles ..... Long Island City, N. Y.
†Friend, W. Z. ..... New York, N. Y.
Frink, Joe ..... Miami, Fla.
Fritts, Charles J. ..... Dallas, Tex.
Fritts, Harry W. ..... New Kensington, Pa.
Friz, Nelson ..... New York, N. Y.
Frizell, Glenn H. ..... Shreveport, La.
†Frye, Seymour Charles ..... Bethlehem, Pa.
Fuchs, Fritz E. ..... Houston, Tex.
Fugazzi, John F. ..... Denver, Colo.
Fujimuro, Masuzo ..... Chiyoda-Ku, Tokvo, Japan
Fuller, Carl T. ..... Houston, Tex.
Fuller, Nelson M. ..... Batavia, N. Y.
Fullerton, F. W. ..... Oklahoma City, Okla.
Fullman, James B. Stamford, Conn.
Funck, Donald E. Manhattan, Kan.
Funk, F. W. ..... Akron, Ohio
Furgason, Clyde A. ..... Cudahy, Wis.
Furth, M. A. ..... Nederland, Tex.

G

Gackenbach, Russell E. ..... Bound Brook, N. J.
Gaido, S. J. ..... Houston, Tex.
Gaidry, H. L. ..... New Orleans, La.
Gaiennie, Ernest S., Jr. ..... New Orleans, La.
Gallagher, John S. ..... Los Angeles, Calif.
Gallup, Dudley D. ..... Thorndale, Pa.
Gally, Sidney K. ..... Pasadena, Calif.
†Gamble, Charles B., Jr. ..... Birmingham, Ala.
†Gamble, George P. St. Louis, Mo.
Gammache, Robert L. ..... Wilmington, Del.
Garber, Glenn D. Lake Charles, La.
†Garcia, Luis ..... Wayne, Mich.
Gard, Charles M. ..... Worthington, Ohio
Gardner, Franklin T. ..... Tulsa, Okla.
Gardner, G. Douglas ..... Louisiana, Mo.
Gardner, Karl A. ..... Massilon, Ohio
Garlock, Neil B. ..... Joplin, Mo.
Garner, Cordelle L. ..... Broussard, La.
Garrett, Fred A. ..... Dallas, Tex.
Garrett, G. H. ..... Denver, Colo.
Garrett, William W. ..... Birmingham, Ala.
Garrison, V. L. ..... Paterson, N. J.
Gartner, Fred W., Jr. ..... Houston, Tex.
Garvin, William H. ..... Dallas, Tex.
Gaston, Don ..... Los Angeles, Calif.
Gates, Harrison L. ..... Chicago, Ill.
*Gattenmeyer, John L. ..... Calgary, Alberta, Canada
Geary, Arthur L. ..... Weirton, W. Va.
Gee, Edwin A. ..... Newport, Del.
Geerlings, Ir H. G. ..... Amsterdam, Netherlands
†Gegner, Paul J. Barberton, Ohio
†Gehres, H. A. Mount Vernon, Ohio
Geissinger, Richard M. ..... Milwaukee, Wis.
Gensberg, Aaron ..... Odessa, Tex.
Georgi, Charles D. St. Louis, Mo.
Gerben, Max ..... Long Island City, N. Y.
German, Alfred New York, N. Y.
German, Commander John P. ..... Miami, Fla.
Gernert, Marvin L. ..... Kingsport, Tenn.
Gerrard, John S. ..... Ahmadi, Kuwait, Persian Gulf Ports
Gerson, Frederick T. ..... London, England
Gettys, Wilbur H. ..... Bartlesville, Okla.
Gibbon, Anthony ..... Tulsa, Okla.
Gibson, Sidney A. ..... Fairfield, Ala.
Giddings, E. W. G. ..... Montreal, Quebec, Canada
†Gieser, Ralph South Gate, Calif.
Gifford, Edmund W. ..... Milwaukee, Wis.
Gilbert, Harry E., Jr. ..... Springdale, Pa.
Gilbert, T. H. Los Angeles, Calif.
Gillan, Howard J. Rochester, N. Y.
Gilliams, Francis B. ..... Philadelphia, Pa.
Gilliland, John L., Jr. ..... Denver, Colo.
Gilmore, Ernest A., Jr. ..... Wichita, Kan.
Givens, Allen T. ..... Monroe, La.
†Glasgow, Clarence O. Tulsa, Okla.
†Glasgow, Robert A. ..... Los Angeles, Calif.
†Glass, D. C. ..... Chicago, Ill.
Gleason, Alvin T. Shreveport, La.
Glenn, Denis Wichita Falls, Tex.
Gleser, Sol M. ..... St. Louis, Mo.
Glidden, William E. Pitman, N. J.
Glover, Manson ..... Malden, Mass.
†Godard, H. P. ..... Kingston, Ontario, Canada
Godfrey, John W. Lockport, N. Y.
Godshalk, James B. ..... Philadelphia, Pa.
Godshall, J. Byron ..... Easton, Pa.
†Goebel, Eugene S. Chicago, Ill.
*Goelzenleuchter, Alvin H. ..... Houston, Tex.
Goen, Paul S. Los Angeles, Calif.
Goit. Laurance E. ..... Los Angeles, Calif.
Goldberg, Gerald J. ..... South Houston, Tex.
†Goldsby, Fred L. New York, N. Y.
Good, Donald Blake, Tulsa, Okla.
†Goodall, R. A. ..... Ogallala, Neb.
Goodell, Robert E. Augusta, Kan.
Goodman, E. E. Granite City, Ill.
Goodman, Winkler W. ..... Cincinnati, Ohio
Goodnight, Robert H. Tulsa, Okla.
Goodrich, C. R. San Antonio, Tex.
Goodson, Loyd Shawnee, Okla.
†Goodwin, Carlton L. ..... Portland, Me.
Goodwin, James M. Somerset, Ohio
Gorden, C. D. ..... Katy, Tex.
Gordon, Maurice B. Baltimore. Md.
Gorman, L. J. Brooklyn, N. Y.
Gosnell, Everett C. Cleveland, Ohio
Gosnell, Kenneth R. ..... Charleston, W. Va.
†Gotsch, L. P. ..... Maywood, Ill.
Gottliebsen, Genius H. ..... Louisville, Ky.
Goudielock, William B. O'Brien ..... New York, N. Y.
Gow, James T. ..... Portland, Ore.
Gowans, Louis L. ..... Honolulu, Territory of Hawaii
Graber, Waldo E. ..... Liberal, Kan.
Graeser, Henry J. ..... Dallas, Tex.
Gragg, William B. ..... Emeryville, Calif.
†Graham, H. W. Pittsburgh, Pa.
Grandi, Alberto ..... Milan, Italy
Grassman, Herbert S. ..... Oak Park, Ill.
Grau, Vicente Massuet ..... Barcelona, Spain
Graves, Colburn R. ..... Long Island City, N. Y.
Graves, J. H. ..... Joinerville, Tex.
Graves, John W. Shreveport, La.
Gray, A. E. Florham Park, N. J.
Gray, R. M. Long Beach, Calif.
Greathouse, Glenn A. ..... Washington, D. C.
Grebe, H. A. ..... Houston, Tex.
Grebe, John J. ..... Midland. Mich.
†Greber, A. C. ..... Cincinnati, Ohio
Grebinar, Herbert L. ..... New York, N. Y.
Grebstad, Ernest H. ..... Los Angeles, Calif.
Greco, Edward C. Shreveport. La.
Green, Donald R. Kalamazoo, Mich.
†Green, E. F. Los Angeles, Calif.
Green, Jerome ..... Chicago, Ill.
†Green, W. A. Little Rock, Ark.
Green, Willis G. ..... Los Angeles, Calif.
Greene, Clifford A. ..... Dallas, Tex.
Greene, John F., Jr. Barber, N. J.
Greene, U. T. ..... Painesville, Ohio
Greenwell, Howard E. Dallas, Tex.
Greer, Norman E. ..... Houston, Tex.
Gregg, Harris T. ..... Houston, Tex.
Gregory, Milton W. Dallas, Tex.
†Gregory, R. P. ..... Houston, Tex.
Gribble, Charles G., Jr. ..... Houston, Tex.
Griffin, Everett M. ..... Birmingham, Ala.
†Griffin, H. K. ..... Meridian, Miss.
Griffith, Darrel F. Victoria, Tex.
Griffith, Dean O. ..... Houston, Tex.
Griffith, T. Ed. ..... Houston, Tex.
Griffiths, Charles W. ..... Camden, N. J.
Griggs, Henry P. ..... Silver Spring, Md.
Griswold, T. N. Ponca City, Okla.
Grizzard, Eugene H. ..... Los Angeles, Calif.
Grogg, Phillip A. St. Louis, Mo.
Grondal, Bror J. Belmont, Mass.
Groom, Claude H. ..... Tulsa, Okla.
Gross, Lewis ..... McAllen, Tex.
Gross, William F. San Diego, Calif.
Grounds, Leo R. ..... Mexico, D. F.
Groves, Ken D. ..... Chicago, Ill.
Gruber, K. A. ..... Long Island City, N. Y.
Guenther, Paul R. Buffalo, N. Y.
Guerry, William A. ..... Little Silver, N. J.
Guinn, C. F. ..... Houston, Tex.
Gumm, Howard W. Houston, Tex.
Gunter, Edgar J. New York, N. Y.
Gurney, William B. ..... Baton Rouge, La.
Gurry, John W. ..... Medford, Mass.
Guthrie, John M. ..... Swissvale, Pa.

H

†Haas, C. A. ..... Houston, Tex.
Haas, D. Marshall Baytown, Tex.
Haas, Nields B. ..... Coraopolis, Pa.
†Haas, W. B. ..... Omaha, Neb.
Haase, Harold F. Milwaukee, Wis.
Hackerman, Norman Austin, Tex.
Hackett, Albert Harold ..... Caracas, Venezuela
†Hackney, R. Peele Richmond, Va.
Haddad, Ibrahim Sami ..... Beirut, Lebanon
Hadley, Raymond F. ..... Philadelphia, Pa.
Haering, Vera W. ..... San Antonio, Tex.
*Hagemeier, Charles E. ..... Houston, Tex.
Hager, Frederick ..... Elmira, Ontario, Canada
Hager, Karl F. Huntsville, Ala.
Hagerman, Charles W. ..... Philadelphia, Pa.
Hagius, Karl S. ..... Colorado Springs, Colo.
Hagstad, Andrew New York, N. Y.
†Hahler, John J., Jr. ..... North Platte, Neb.
Hahn, A. H. ..... Tulsa, Okla.
Haile, Edward L. Texas City, Tex.
Halbig, John J. Middletown, Ohio
†Hale, Robert L., Jr. ..... Lake Charles, La.
Hale, William L. Brooklyn, N. Y.
Halff, Albert H. ..... Dallas, Tex.
Hall, Elwin B. ..... Los Angeles, Calif.
Hall, George D. ..... Houston, Tex.
Hall, Kenneth G. Elizabeth, N. J.
Hall, Marvin F. Washington, D. C.
Hall, Nathaniel ..... Newark, N. J.
Hall, R. E. ..... Brea, Calif.
Hall, William A. Philadelphia, Pa.
Hall, W. Quentin ..... Baton Rouge, La.
Hallden, John T. ..... Rockford, Ill.
Halley, James W. ..... East Chicago, Ind.
Halloran, William D. Houston, Tex.
Halsell, Hampton L. ..... Fayetteville, Ark.
Halsted, Hal F. ..... Altadena, Calif.
Haltom, Forrest E. ..... Port Arthur, Tex.
Haltom, J. Myrl ..... Dallas, Tex.
Hamann, Charles E. ..... West Lynn, Mass.
Hamilton, Archer B. ..... Hartford, Conn.
Hamilton, Hugh L. ..... Bala-Cynwyd, Pa.
Hamilton, J. S. ..... New Kensington, Pa.
Hamilton-Smith, A. ..... Kent, England
Hamlin, Arthur W. ..... New York, N. Y.
Hamlin, George O. ..... Corpus Christi, Tex.
Hammer, William A. Houston, Tex.
Hammond. Milton B. ..... Edgeworth Sewickley, Pa.
Hamstead, A. C. ..... South Charleston, W. Va.
Hancock, Charles W. Nowata, Okla.
Hanes, Henry W. Jacksonville, Tex.
Haney, Charles E. ..... San Francisco, Calif.
Hansen, Arnold William ..... Milwaukee, Wis.
Hansen, Eugene R. Houston, Tex.
Hansen, Tolbert L. ..... Dhahran, Saudi, Arabia
Hanson, Melvin A. ..... Bloomington, Ill.
Happ, Charles R. Port Arthur, Tex.
†Harbaugh, R. L. ..... East Chicago, Ind.
Harbison, Dixon T. ..... Fort Worth, Tex.
Hardaway, Rex L. ..... Corpus Christi, Tex.
Harden, Gail D. East Chicago, Ind.
Harder, Robert G. Pittsburgh, Pa.
Hardman, James T. Tulsa, Okla.
Hardy, Ivan C. ..... Ottawa, Ontario, Canada
Hargroder, A. D. ..... Lake Charles, La.
Harker, Thomas W. ..... Morton Grove, Ill.
Harman, George Robert ..... Pittsburgh, Pa.
Harnsberger, A. E. Chicago, Ill.
Harper, George M. Abbeville, La.
†Harris, Jack W. ..... Houston, Tex.
Harris, John J. ..... Dallas, Tex.
Harris, Lester K. Bethlehem, Pa.
Harrison, Gordon D. ..... Knoxville, Tenn.
Hart, James L. Bartlesville, Okla.
Hart, M. B. ..... Brookfield, Ill.
Hart, Porter ..... Freeport, Tex.
Hartkemeier, Leonard W. ..... Golden, Colo.
Hartley, Harry A. Cleveland, Ohio
Hartman, H. F. ..... Baytown, Tex.
Hartwell, Richard R. Maywood, Ill.
Hartwick, Otto J. ..... Houston, Tex.
†Harvey, C. C. Baton Rouge, La.
Harwood, Julius J. ..... Washington, D. C.
†Hasenritter, Delmar St. Louis, Mo.
Haskins, Frank D. ..... Flint, Mich.
Hatch, George B. Pittsburgh, Pa.
Hatchett, V. W. ..... Augusta, Kan.
Hatfield, Homer F. Allentown, Pa.
Hausman, John C. Harrisburg, Pa.
Hawke, David L. Brooklyn, N. Y.
Hayner, Donald L. ..... Milwaukee, Wis.
Haynes, Harold J. ..... New Orleans, La.
Hazzard, F. W. Chattanooga, Tenn.
Healey, Edward Lewis ..... Sayville, N. Y.
Heath, John R. ..... Cleveland, Ohio
Heatley, David J. Houston, Tex.
Hecht, Leon M., Jr. ..... Nashville, Tenn.
Hecht, Max ..... Drexel Hills, Pa.
Hedborg, Carl E. ..... Brea, Calif.
Hedges, Eugene B. Saginaw, Mich.
Hedrick, H. M. Long Beach, Calif.
Heger, J. J. ..... Pittsburgh, Pa.
Heideman, William A. ..... East St. Louis, Ill.
Heil, Carl E. ..... Cleveland, Ohio
Heinemann, Gustave ..... Corpus Christi, Tex.
Heinen, Lawrence E. Houston, Tex.
Heinzerling, Robert F. ..... Bloomfield, N. J.
Heiss, Franklin S. D. ..... Philadelphia, Pa.
Heitman, Talmage M., Jr. ..... Houston, Tex.
†Helmbrecht, A. J. ..... New York, N. Y.
Helmrath, Norman K. ..... Chicago Heights, Ill.
Helms, Robert F. Lafayette, La.
Henderson, E. L. Shreveport, La.
Henderson, Mervin W. ..... Springfield, Mo.
Henderson, Oliver Cleveland, Ohio
Henderson, Walter A. ..... New York, N. Y.
†Hendrickson, David ..... Oakland. Calif.
Henry, Ernest L. Cleveland, Tex.
Henry, R. E. ..... Longview, Tex.
Herberg, William F., Jr. ..... Houston, Tex.
Herbst, Irene A. Milwaukee, Wis.
Herman, Theodore H., Jr. ..... Washington, D. C.
†Herringshaw, D. E. ..... Jackson, Mich.
Herrmann, Hans ..... Newark, N. J.
Hersam, G. Russell ..... New York, N. Y.
Herstein, Frederick E. ..... Plainfield, N. J.
Hertel, Wallace E. ..... Lake Geneva, Wis.
Herzler, Ralph E., Jr. Chicago, Ill.
Herzog, Max A. ..... Springfield. Mo.
Hess, Albert W. ..... Camden, N. J.
Hess, Fred E. ..... Fort Worth, Tex.
†Hess, W. T. ..... New Orleans, La.
Hetzel, Harry T. Blawnox, Pa.
Heverly, L. F. Kansas City, Kan.
Hewitt, Harry N. ..... Montreal East, Canada
Hibbs, Don B. ..... Kansas City, Mo.
Hibler, Marion Y. ..... Port Arthur, Tex.
Hickethier, Carlos F. ..... Buenos Aires, Argentina
Hickey, Robert P. Trenton, Mich.
Hicks, Charles P. New York, N. Y.
Hieronymus, Frantz M. ..... Tulsa, Okla.
Hiers, George O. Brooklyn, N. Y.
Higburg, William Indianapolis, Ind.
Higgins, Edward J. ..... Westfield. N. J.
Higgins, Howard L. Lorain, Ohio
Higgins, J. D., Jr. ..... Fort Worth, Tex.
Higgins, Waldo W. Kankakee, Ill.
Hilbert, Edwin W. ..... New York, N. Y.
Hiley, R. B. ..... Harrison, N. J.
Hill, David L. ..... Detroit, Mich.
Hill, George R. ..... Salt Lake City, Utah
†Hill, Leonard C. Hastings, Neb.
Hill, Preston W. ..... Long Beach, Calif.
Hill, Roy W. ..... Fort Belvoir, Va.
Hill, Wallace T. Owatonna, Minn.
Hilton, Robert W. ..... Valley Stream, N. Y.

Himmelrich, John Earle
Pittsburgh, Pa.
Himmler, Alden C. Hollywood, Md.
Hinchman, William H. D.
Detroit, Mich.
Hinckley, Arthur T.
Niagara Falls, N. Y.
Hind, Harry L. Boston, Mass.
Hinkle, George S., Jr.
Houston, Tex.
Hirshfeld, James F. Detroit, Mich.
†Hobbs, W. H. St. Louis, Mo.
Hocker, Charles Richard
Basking Ridge, N. J.
Hodson, Fred W.
Corpus Christi, Tex.
Hoeveler, J. H., Jr.
New York, N. Y.
Hoffer, George Victoria, Tex.
Hoiberg, Arnold J. El Dorado, Ark.
Holcomb, William D. Chicago, Ill.
Holcombe, Tom L. Shreveport, La.
Holland, Charles J., Jr.
Dallas, Tex.
Holler, Homer D. Chevy Chase, Md.
Holloway, J. A. Edna, Tex.
Holm, Emil G. Houston, Tex.
†Holmberg, Emil G. Linden, N. J.
Holmberg, M. E. Houston, Tex.
Holmes, Laird E. Robinson, Ill.
Holsteyn, Derk Houston, Tex.
Holt, James B. Dallas, Tex.
Holtman, Clemens W.
Louisville, Ky.
Holtzapple, Frank R. Alvin, Tex.
†Holtzscher, George A., Jr.
Granite City, Ill.
Honecker, Walter C.
Indianapolis, Ind.
†Honkala, H. E. Decatur, Ala.
Honovich, Joseph F., Jr.
Shreveport, La.
Hookanson, Kenneth G.
Morton Grove, Ill.
Hookway, William C., Jr.
Hillside, N. J.
Hooper, Raymond R.
New York, N. Y.
Hopkins, Arthur James
Melbourne, Victoria, Australia
Hopkins, James L. Columbus, Ohio
Hopkins, John R. Englewood, Colo.
Hopkins, W. H. Houston, Tex.
†Hopper, E. W. Pittsburgh, Pa.
Horne, Albert N.
Toronto, Ontario, Canada
†Horner, William L. Tulsa, Okla.
Horst, Ralph L., Jr.
New Kensington, Pa.
†Horstman, W. G. Atlanta, Ga.
Hort, Percy Philadelphia, Pa.
Horton, James B. Bethlehem, Pa.
Horton, John Leroy Natchez, Miss.
Horton, Roy Tulsa, Okla.
Horvath, Louis Cleveland, Ohio
Hose, Alfred G. Cleveland, Ohio
Hosford, Harry W. Cleveland, Ohio
Howald, Thomas S. Euclid, Ohio
Howard, Owen G. Toledo, Ohio
Howell, John C. Maplewood, N. J.
*Howell, Kenneth S. Houston, Tex.
Howell, R. P. San Francisco, Calif.
Hoxeng, Raymond B.
Pittsburgh, Pa.
†Hoyt, W. B. New York, N. Y.
Hubard, Stephen S.
Baltimore, Md.
Huckleberry, S. A.
Corpus Christi, Tex.
Huddleston, Charles E., Jr.
Beaumont, Tex.
Huddleston, William E.
Bartlesville, Okla.
Hudgens, Ellsworth W.
Tulsa, Okla.
Hudock, George W.
Park Forest, Ill.
Hughes, Charles F.
Port Arthur, Tex.
Hughes, H. D. Dallas, Tex.
Hughes, Henry M. Tulsa, Okla.
Hughes, Homer L.
Farmington, Mo.
Hugo, L. A. Bartlesville, Okla.
Huitt, Troy L. Philadelphia, Pa.
Huley, Louis B. Dallas, Tex.
Hull, George C., Jr.
Newark, N. J.
Humber, Joe B. Texas City, Tex.
†Humble, H. A. Midland, Mich.
Hummon, C. Gerald
Kansas City, Mo.
Humphries, Thomas Smith, Jr.
New Kensington, Pa.
Hunt, A. J. Odessa, Tex.
Hunt, Bill E. Chicago, Ill.
Hunter, Felix A. Sweeny, Tex.
Hunter, J. N., Jr. Tulsa, Okla.
Hunter, Ralph M. Midland, Mich.
Huntley, Harold R.
New York, N. Y.
Hur, J. James Philadelphia, Pa.
Hurley, E. T.
Montreal, Quebec, Canada
Hurst, Ralph Jackson, Miss.
Hurst, S. London, England
Hurtado, J. R.
Caracas, Venezuela, South America
Hurtgen, Archibald Louisville, Ky.
Huscher, Joseph L. Bedford, Ohio
Huseby, Robert A. Milwaukee, Wis.
Husock, Bernard Cleveland, Ohio
*Hustead, B. G. Kilgore, Tex.
Huston, Kenneth M.
Baltimore, Md.
†Hutchcraft, D. K. Olean, N. Y.
Hutchinson, Carroll O. Chicago, Ill.
Hutchinson, Gilbert E.
Midland, Pa.
Hutchison, John S. Tulsa, Okla.
Hutchison, William A.
Independence, Kan.
Huth, Eugene G. Cleveland, Ohio
Hutzler, George J.
Philadelphia, Pa.

I

Imhoff, Carroll E. Milwaukee, Wis.
Ing, Clayton V., Jr.
Ft. Worth, Tex.
Ingels, G. R. Houston, Tex.
Ingham, Herbert S.
Long Island City, N. Y.
Ingram, Sidney M. Shreveport, La.
Irish, Lynton B. Shreveport, La.
Irvin, James A. Shreveport, La.
Irving, Ralph Houston, Tex.
Irwin, C. A. Brownsville, Tex.
Isaacks, Albert N.
Drexel Hills, Pa.
†Isherwood, J. H.
Port Allegany, Pa.
Isles, Frederick W. Linden, N. J.
Ivanso, Eugene V.
Ann Arbor, Mich.

J

Jackson, C. M. Louisville, Ky.
Jackson, J. Harry Columbus, Ohio
Jackson, James O. Pittsburgh, Pa.
†Jackson, Maynard H. Tulsa, Okla.
Jackson, Robert M.
Rochester, N. Y.
Jackson, Russell Phoenix, Ariz.
Jackson, Willis E. Toledo, Ohio
Jacobek, Warren G.
Forest Park, Ill.
Jacobson, Murray
Watertown, Mass.
Jahnke, Louis P. Hamilton, Ohio
James, Harry C.
Niagara Falls, N. Y.
James, H. E. Jackson, Miss.
James, Jay R. Tulsa, Okla.
James, Paul W. Syracuse, N. Y.
Janke, Peter L. Chicago, Ill.
Janota, Rudolph B. Chicago, Ill.
†Jared, John B., Jr. Houston, Tex.
Jay, Lester L. New Iberia, La.
Jay, Webb Lafayette, La.
Jednacz, John E. Philadelphia, Pa.
Jeffares, George M. Atlanta, Ga.
Jehu, Llewellyn, Jr.
Lachine, Quebec, Canada
Jekot, Chester M. Chicago, Ill.
Jelen, Frederic C. Syracuse, N. Y.
Jelinek, Frank R.
Port Neches, Tex.
Jenkins, Clark L. Houston, Tex.
†Jenkins, Vance N. Brea, Calif.
Jenner, William C.
Cleveland, Ohio
Jennings, Carl H. Fort Worth, Tex.
Jensen, Claude H. Glassport, Pa.
Jensen, O. L. Bellwood, Ill.
Jenss, Alfred D. Cincinnati, Ohio
Jessen, Frank W. Austin, Tex.
Jewell, James G. Pittsburgh, Pa.
Joecks, Adolph K. New York, N. Y.
Johannes, E. Gent St. Louis, Mo.
Johannesen, Clifford W.
Los Angeles, Calif.
Johnquest, Harry M.
Waterbury, Conn.
Johns, Donald H. St. Louis, Mo.
Johnsen, Walter
Staten Island, N. Y.
Johnson, Carl R. New York, N. Y.
Johnson, Carl V. Philadelphia, Pa.
Johnson, Clement O.
Jacksonville, Fla.
Johnson, Dewey W. Chicago, Ill.
Johnson, Earl A. N.
Shelton, Wash.
Johnson, Elmer A. Lincoln, Calif.
Johnson, Ernest B. Tulsa, Okla.
†Johnson, Felix M.
Oklahoma City, Okla.
Johnson, Gerald M.
Fort Worth, Tex.
Johnson, Herbert S.
Shawinigan Falls, Quebec, Canada
Johnson, J. F., Jr.
Zionsville, Ind.
Johnson, R. K. New York, N. Y.
Johnson, Robert L. Jackson, Mich.
Johnson, Robert T. Freeport, Tex.
Johnson, Thomas E. Freeport, Ill.
Johnson, W. A.
Melbourne, Australia
Johnson, Wayne A. Houston, Tex.
Johnson, Wm. W.
Port Arthur, Tex.
Johnson, Walter C. Columbus, Ohio
Johnston, Donald P.
Carlsbad, Calif.
Johnston, Howard E.
New York, N. Y.
Johnston, John E.
Oklahoma City, Okla.
Johnston, J. Flynn Atlanta, Ga.
Johnston, Thomas A., Jr.
Mobile, Ala.
Jones, Charles C. Philadelphia, Pa.
Jones, Charles H.
Bogota, Colombia, S. A.
Jones, David T.
North Hollywood, Calif.
Jones, Elmer H.
Los Angeles, Calif.
†Jones, G. C. Jackson, Miss.
Jones, Gaston V. Shreveport, La.
Jones, Henry P.
Salt Lake City, Utah
Jones, Jesse C. Newport News, Va.
Jones, R. M. Caracas, Venezuela
Jones, William E.
Santa Clara, Calif.
Jopp, J. M.
La Tuque, Quebec, Canada
Jorczak, Joseph S. Trenton, N. J.
Jordan, Harry E. New York, N. Y.
Jordan, Melvin N. Kermit, Tex.
Jordan, Philip R. Mishawaka, Ind.
Jordan, Raymond C.
Shreveport, La.
Jorgensen, Roy C. Freeport, Tex.
Joy, Austin S. Wilmington, Calif.
Joyce, Edwin Dallas, Tex.
Judah, Lt. (jg) Melvin A.
San Francisco, Calif.
Juppenlatz, John W. Lebanon, Pa.
Jurs, Peter C. Berkeley, Calif.
Juster, Maurice W.
East Chicago, Ind.

K

Kahler, H. Lewis Philadelphia, Pa.
Kahler, Leroy P.
Jersey City, N. J.
Kahn, Frank Philadelphia, Pa.
Kahn, Walter C., Jr.
Hazleton, Pa.
Kaim, Fred J. Minneapolis, Minn.
Kalhauge, Viggo M. Chicago, Ill.
Kamps, Julius M. Pittsburgh, Pa.
Karger, Frank S. Chicago, Ill.
Karlskind, Don B.
Little Rock, Ark.
Karraker, Ed. L. Waltham, Mass.
†Kartinen, E. O.
Los Angeles, Calif.
*Kasper, Gordon Emil
Los Angeles, Calif.
Kaster, J. W. Tulsa, Okla.
Kaszynski, John F. Chicago, Ill.
Kauffman, David S.
Independence, Kan.
Kaufman, L. W. Mansfield, Ohio
Kaufmann, D. W. Buffalo, N. Y.
Kavenaugh, James A.
Los Angeles, Calif.
Kayser, James N.
North Baton Rouge, La.
Kean, E. E., Jr. Columbus, Miss.
†Keane, C. C. Kansas City, Mo.
Keaney, J. C. Pittsburgh, Pa.
Keaton, Lawrence C. Borger, Texas
*Kedzie, Donald P.
Milwaukee, Wis.
Keeling, Harry J.
Los Angeles, Calif.
Kellam, G. D.
Calgary, Alberta, Canada
Keller, A. V. Gering, Neb.
Keller, Ralph W.
Colorado City, Tex.
Keller, Richard M.
Philadelphia, Pa.
Keller, W. H. St. Louis, Mo.
Keller, Wayne H. St. Louis, Mo.
Kelley, Howard M.
Hyde Park, Mass.
Kelley, John H. Baltimore, Md.
Kellogg, Andrew Syracuse, N. Y.
Kelly, Bernard J. Pittsburgh, Pa.
Kelly, J. Dyche Houston, Tex.
Kelly, R. W. Tulsa, Okla.
†Kelly, Thomas F. P.
Houston, Tex.
Kelly, Warner M. Houston, Tex.
Kemp, James T. Washington, D. C.
Kemper, E. O. Odessa, Tex.
Kenan, Robert C. Chicago, Ill.
†Kendall, V. V. Pittsburgh, Pa.
Kendrick, J. L. Kenner, La.
Kennedy, Carl M. Springfield, Ill.
Kennedy, Harvey T.
College Station, Tex.
Kennedy, Ted Ann Arbor, Mich.
Kennedy, W. L., Jr. Tulsa, Okla.
Kennison, Hugh F.
East Orange, N. J.
Kepley, Charles L.
Melvindale, Mich.
Kern, George F., Jr.
Wilmington, Del.
Kerns, Everette E. Cleveland, Ohio
Kerr, Robert Hartley
Los Angeles, Calif.
Kerschner, Edward
Philadelphia, Pa.
Kerstein, Norman A. Detroit, Mich.
Kessler, Kenneth K.
Baltimore, Md.
Ketcham, Brower
San Francisco, Calif.
Kettron, Henry P. Macomb, Ill.
Keyt, Ernest B. El Segundo, Calif.
Kiefer, George C.
Brackenridge, Pa.
Kiefer, James M. Chicago, Ill.
Kilberg, Bernard Moline, Ill.
Kilday, John A. Hamilton, Ohio
Kimbro, A. M. Houston, Tex.
Kimmel, Albert L.
Gainesville, Fla.
Kimen, Peter A. Pasadena, Tex.
Kinelski, Eugene H.
Hammond, Ind.
King, Robert J. Barber, N. J.
Kinley, John C. Houston, Tex.
Kinnear, Robert C.
Port Neches, Tex.
Kinney, Wayne L. Chicago, Ill.
†Kipp, E. M. New Orleans, La.
Kirkendall, William E.
Los Angeles, Calif.
Kirkpatrick, James L. Dallas, Tex.
Kirkpatrick, Willard H.
Sugar Land, Tex.
Kirsten, K. W. Dallas, Tex.
Kirwin, James E.
Aruba, Netherlands West Indies
Kizer, Curtis A. New Iberia, La.
Kizer, F. H. Lake Charles, La.
Klassen, Clarence W.
Springfield, Ill.
†Klauber, L. M. San Diego, Calif.
Kleber, John P. Pittsburgh, Pa.
Kleefisch, William St. Louis, Mo.
Kleespies, Henry S., Jr.
Port Arthur, Tex.
Klein, Fred M. New York, N. Y.
Klein, James C. Owensboro, Ky.
†Kleinheksel, S. Plainfield, N. J.
Klever, Charles F. Omaha, Neb.
Klinger, John C. Bayonne, N. J.
Klinger, Lloyd L.
Wisconsin Rapids, Wis.
Klinger, O. C. Bayonne, N. J.
Klopp, Edward M. Cleveland, Ohio
Kluender, Arnold F. Chicago, Ill.
Klumb, George H. Northbrook, Ill.
Klumb, Harvey J. Rochester, N. Y.
†Knapp, Alfred P.
Long Island City, N. Y.
Knapp, Frederick F.
Fort Morgan, Colo.
†Knight, C. A. Beaumont, Tex.
Knopp, Harold P. Oakland, Calif.
Knowlton, A. E. New York, N. Y.
Knowlton, Drexel R. Avenal, Calif.
Knox, John A. Midland, Tex.
Koeckritz, E. Paul, Jr.
Los Angeles, Calif.
Koehler, Donald N.
Milwaukee, Wis.
Koehler, W. A.
Morgantown, W. Va.
Koenig, E. A. Shreveport, La.
Koester, H. F. New York, N. Y.
Koger, William C.
Great Bend, Kan.
Kolzow, Clarence R. Elmhurst, Ill.
Kopetz, George E., Pittsburgh, Pa.
Kopp, C. H. Oklahoma City, Okla.
Koppl, Frederick Phoenix, Ariz.
Kopplin, Julius O.
Hammond, Ind.
Kosik, John A. Chattanooga, Tenn.
*Kozakis, Achilles Houston, Tex.
*Krch, Milford F. Beaumont, Tex.
Krell, Abraham J. Houston, Tex.
Kretschmer, William J.
Columbus, Ohio
Krickl, Joseph L., Jr.
Maywood, Ill.
Krikscus, Paul, Jr.
Los Angeles, Calif.
Krockmalski, Edward
Corning, N. Y.
Kroon, Harry E. Chicago, Ill.
Krueger, Forrest J.
New York, N. Y.
Krueger, Jess J. Omaha, Neb.
Krueger, Louis T. Casper, Wyo.
†Kruger, R. E. Rochester, N. Y.
Kruszynski, Edward A.
St. Louis, Mo.
Krystow, Paul Jersey City, N. J.
Kuehnle, C. Albert, Jr.
Baltimore, Md.
Kuhlmann, Frank H.
St. Louis, Mo.
Kuhn, Cyril D. Houston, Tex.
Kuhn, Robert J. New Orleans, La.
Kulman, Frank E.
New York, N. Y.

Kuniansky, I. Atlanta, Ga.
Kunz, Earl F. Cleveland, Ohio
†Kunz, Miles C. Newark, N. J.
Kurtis, Soma Detroit, Mich.

L

Lachmund, D. O. Newark, N. J.
Lacy, J. Glen South Gate, Calif.
Ladd, Glenn L. Independence, Kans.
Ladd, Raymond J. Midland, Mich.
Laenger, Ralph E. Beeville, Tex.
Lafever, Mortier, Jr. Washington, D. C.
†La Fortune, J. A. Tulsa, Okla.
Lain, George D. New York, N. Y.
Lake, Francis J. Flushing, N. Y.
Lambert, Frank J., Jr. Oak Ridge, Tenn.
Lambert, William R. Waynesburg, Pa.
Landreneaux, John M., Jr. Basile, La.
Lane, Bruce S. Kalamazoo, Mich.
†Lane, H. S. Houston, Tex.
Lane, Montie J. Philadelphia, Pa.
Lane, Russell W. Champaign, Ill.
Lang, Albert A. Cleveland, Ohio
Lang, Frances S. New York, N. Y.
Lang, Franklin New York, N. Y.
Langhans, Oscar Harvey, La.
Lanphier, Basil T. Reading, Pa.
LaQue, F. L. New York, N. Y.
†Larrabee, C. P. Vandergrift, Pa.
Larson, John A. Evanston, Ill.
Larson, Thurston E. Urbana, Ill.
Laster, Gaines Tulsa, Okla.
Lastrapes, Richard L. Beaumont, Tex.
Lataille, Lester W. Honolulu, Territory of Hawaii
Latham, Wallace L. Oklahoma City, Okla.
Lattin, Benton C. Scarsdale, N. Y.
Lautner, Robert B. Baton Rouge, La.
Lavery, C. A. Tulsa, Okla.
Law, John E. Oak Park, Ill.
Law, Robert J. Toronto, Canada
Lawall, Russell M. Oberlin, Ohio
†Lawless, Sydney New York, N. Y.
Lawlor, E. W. Tulsa, Okla.
Lawn, Raymond J. Pittsburgh, Pa.
Lawrence, J. C. Twinsburg, Ohio
Lawrence, R. E., Jr. Tarboro, N. C.
†Lawson, J. M. Lemont, Ill.
Lawton, Ledra M. Lockport, N. Y.
Lay, Albert F. Houston, Tex.
Layne, Harold B. Colorado City, Tex.
Leary, John D. Corpus Christi, Tex.
Leas, A. Robert Washington, D. C.
LeBlanc, Roland L. Maplewood, La.
Lebrecht, G. Frank St. Louis, Mo.
Lecoff, Jesse Philadelphia, Pa.
Lecourt, Stanley M. New Orleans, La.
Ledbetter, Buford P. Corpus Christi, Tex.
Lederer, Lewis M. Cincinnati, Ohio
Ledford, Robert C. Houston, Tex.
Lee, B. C., Jr. Norfolk, Va.
Lee, Bertrand Edward, Sr. Atlanta, Ga.
Lee, Charles E. Los Angeles, Calif.
Lee, Robert H. Indianapolis, Ind.
Lee, R. P. South Amboy, N. J.
Leedom, Laurie M. Bloomfield, N. J.
Lefebvre, Fabian J. Newark, N. J.
Lehmann, Joseph A. New York, N. Y.
Leister, John A. Pittsburgh, Pa.
Lemay, Jack E. Dallas, Tex.
Lembcke, Richard E. Tallant, Okla.
Lendved, John W., Milwaukee, Wis.
Leonard, Robert E. Wilmington, Del.
Leonardon, Eugene Gilbert Houston, Tex.
Leonhard, Frederick J. Cleveland, Ohio
Lepley, Raymond D. Philadelphia, Pa.
Leroy, Royce H. College Station, Tex.
Lester, C. B. Longview, Tex.
Lester, Louis B. Los Angeles, Calif.
Levert, William F. Shreveport, La.
Levinson, Irving S. Milwaukee, Wis.
†Levy, David Henry Dallas, Tex.
Levy, Max M., Jr. Houston, Tex.
Lewis, L. G. Midland, Tex.
Lewis, Robert H. Fort Lauderdale, Fla.
Lewis, Sidney A. Newark, N. J.
Lewis, Walter T. Houston, Tex.
Liebhafsky, Herman A. Schenectady, N. Y.
Liebman, Arno J. Pittsburgh, Pa.
Liggett, Ernest J. Tulsa, Okla.
Ligon, John R. Fort Worth, Tex.
Lima, D. O. Oklahoma City, Okla.
Limata, Albert J. New York, N. Y.
Lindberg, Jay G. Provo, Utah
Lindberg, Ramon I. Harvey, Ill.
Lindemann, Ervin Minneapolis, Minn.
Lindsay, J. D. College Station, Tex.
Lineback, George A. Cincinnati, Ohio
Linford, Henry B. New York, N. Y.
Lingle, Robert J. Houston, Tex.
Lithgow, James Los Angeles, Calif.
Littreal, William Bernard Salt Lake City, Utah
Livengood, Robert G. Shreveport, La.
†Lobanoff, Val Oakland, Calif.
Lobley, F. A. Elkhart, Ind.
Lobo, Humberto, Jr. Monterrey, N. L., Mexico
Locheed, E. W. Houston, Tex.
†Locke, Giles Youngstown, Ohio
†Lockeman, George F. Cincinnati, Ohio
Lockwood, C. J. Beaumont, Tex.
Lockwood, Luther E., Maywood, Ill.
Loeffler, John Edward Houston, Tex.
Loeffler, William J. Providence, R. I.
Logan, Campbell F. Jacksonville, Fla.
Logan, Kirk H. Washington, D. C.
Logan, Robert L. Chicago, Ill.
†Lomax, O. Q. Houston, Tex.
Lombardo, Flora South Gate, Calif.
Long, Alfred Joliet, Ill.
†Long, Dan P. Amarillo, Tex.
Longley, James E. East Orange, N. J.
Loos, De Lasso Midland, Tex.
Lopata, Stanley L. St. Louis, Mo.
Lopez, Eugene R., New York, N. Y.
Loprete, Jack H. Detroit, Mich.
Lorber, Robert P. Springfield, Mass.
Loucks, Charles M. Cleveland, Ohio
Loudenback, Clyde I. Chicago, Ill.
Love, Billy Ray Carrizo Springs, Tex.
Love, Frank H. Dallas, Tex.
Love, James L. Lafayette, La.
Lovelady, H. A. Tulsa, Okla.
Lovell, Odus W., Jr. Petal, Miss.
Lovoi, Frank J. Houston, Tex.
Lowe, Marvin E. Barranquilla, Colombia, S. A.
Lowe, Richard A. Maracaibo, Venezuela
Lowenheim, Frederick A. Rahway, N. J.
†Lowerre, R. T. Cleveland, Ohio
†Lowther, G. B. St. Louis, Mo.
Loyd, Clyde C. Baton Rouge, La.
Luce, Walter A. Dayton, Ohio
Luger, Karl E. Houston, Tex.
Luichinger, Martin J. Indianapolis, Ind.
Lundberg, H. E. Stamford, Conn.
Lundy, Daniel A. Los Angeles, Calif.
†Lungren, E. E. Chicago, Ill.
Lutjens, Fred H. Sioux City, Iowa
Lutsch, William A. Detroit, Mich.
Luttrell, William T. Downingtown, Pa.
†Lynch, Robert H. Philadelphia, Pa.
Lynes, Wilson Rome, N. Y.
Lyon, Edwin, Jr. Ambridge, Pa.
Lyon, John A. M. Evanston, Ill.
Lyons, Robert H. Chicago, Ill.
Lyons, William C. Fort Worth, Tex.

M

Mabrey, W. L. Tulsa, Okla.
MacCollum, Donald R. Rochester, N. Y.
MacCorkle, Daniel S. New York, N. Y.
MacCormack, Robert S., Jr. Mountain Lakes, N. J.
*MacDonald, A. John Pittsburgh, Pa.
MacDonald, Frank P. Chicago, Ill.
Mace, A. E. Media, Pa.
MacGregor, Alfred H. Webster Groves, Mo.
Mach, Walter W. Wichita, Kan.
Machado, Oscar Caracas, Venezuela, S. A.
Macias-Rendon, Fernando Blacksburg, Va.
Mack, David J. Madison, Wis.
MacKenzie, James T. Birmingham, Ala.
MacKenzie, John Brown, Jr. Houston, Tex.
Madden, R. C. Fontana, Calif.
Maddigan, S. E. Vancouver, B. C., Canada
Maddox, Melvin E. Little Rock, Ark.
Madero, Carlos F. Monterrey, Mexico
Madigan, James F. Great Neck, N. Y.
Maggiacomo, Sam Toronto, Canada
Magoffin, Linn E. National City, Calif.
†Maher, D. W. Detroit, Mich.
†Mahoney, E. J., Jr. Lansing, Mich.
Main, Merrill M. Chicago, Ill.
Maitland, T. J. New York, N. Y.
Major, Lewis A. Alexandria, Va.
†Malcom, V. V. Cincinnati, Ohio
Maloney, Eugene E. Buffalo, N. Y.
Maloney, Richard W. Los Angeles, Calif.
Malouf, E. E., Salt Lake City, Utah
Manahan, William A. Long Beach, Calif.
Mandley, John O. Detroit, Mich.
†Mankin, Paul A. Fort Wayne, Ind.
Mange, Clarence E. St. Louis, Mo.
Manley, Harold W. Tulsa, Okla.
†Mann, L. D. Lake Charles, La.
Manninen, Thomas H. Baltimore, Md.
†Manning Paul D. V., Chicago, Ill.
Maradudin, Alexei P. El Segundo, Calif.
Markham, Wendell G. Long Beach, Calif.
Markle, Mathew G., Bellwood, Ill.
Marlin, Donald H., Pittsburgh, Pa.
Marquez, Edward B. New Orleans, La.
†Marrinan, J. W., Pittsburgh, Pa.
Marshall, Dwight, New York, N. Y.
Marshall, Fred D. Los Angeles, Calif.
Marshall George W. Lennoxville, Quebec, Canada
Marshall, Robert P., Detroit, Mich.
Martin, Arthur R., Milwaukee, Wis.
Martin, Harry C. Monroe, La.
Martin, Jack T. New Orleans, La.
Martin, James H., Jr. Baytown, Tex.
Martin, Paschal Chicago, Ill.
Martin, Robert C. Atlanta, Ga.
Martin, W. Edgar San Francisco, Calif.
Marx, Paul F. Bradford, Pa.
Masin, Charles B. Denver, Colo.
Mason, John F., Jr. New York, N. Y.
Mason, John R. Tulsa, Okla.
Massing, Robert W., Chicago, Ill.
Mathers, W. D. Tenafly, N. J.
†Matheson, E. E. Pittsburgh, Pa.
†Matson, Eugene M., Chicago, Ill.
Matthews, James C., Houston, Tex.
Matthews, R. F. Tulsa, Okla.
Mauney, L. M. Tulsa, Okla.
Maw, J. T. Cartagena, Colombia, S. A.
Maxwell, Eugene C., Denver, Colo.
May, Kendall B., Ann Arbor, Mich.
May, Thomas P., New York, N. Y.
Mayer, William J., Baltimore, Md.
†Mayer, William M. Corpus Christi, Tex.
Mayes, Edward San Francisco, Calif.
Mayes, H. B. Houston, Tex.
†Mayo, E. E., San Francisco, Calif.
McAninch, Don L. Pearland, Tex.
McAnneny, Adrian W. Houston, Tex.
McAuliff, John P. Oklahoma City, Okla.
McBrien, James H. Tulsa, Okla.
McCabe, Joseph C. New York, N. Y.
McCall, Richard H., Houston, Tex.
McCallum, Walter C., Jr. Sulphur, La.
McCamish, Harley Milton Concord, Calif.
†McCammon, G. A. Caracas, Venezuela, S. A.
McCann, Sidney W. Rochester, N. Y.
McCarthy, Robert A., Dallas, Tex.
McCaslin, Kenneth M. South Gate, Calif.
McCauley, E. D., Birmingham, Ala.
McCauley, George M., Atlanta, Ga.
McClenahan, W. T., Chicago, Ill.
McClintock, Oliver, Sewickley, Pa.
McClintock, Robert D. Waukesha, Wis.
McCloud, Dwite M. La Habra, Calif.
McCluskey, Francis J. St. Louis, Mo.
McComas, John Q. Beverly Hills, Calif.
McComb, George B., St. Louis, Mo.
McConnell, Alexander, Cudahy, Wis.
McConnell, Fred M. Los Angeles, Calif.
McConomy, Henry F. Philadelphia, Pa.
McCormick, Lawrence O. Baltimore, Md.
*McCullough, Harold M. Flushing, N. Y.
McCullough, Orgain E., Jr. Pittsburgh, Pa.
McCusker, William A. Baltimore, Md.
McCutchen, Charles W. Freeport, Tex.
McCutcheon, C. Alan St. Davids, Pa.
McDaniel, John P., Houston, Tex.
McDermott, Byron Oklahoma City, Okla.
†McDermott, Franklin New York, N. Y.
McDonald, Herschel C. San Antonio, Tex.
McDonald, Lawrence L. Chicago, Ill.
McDonald, T. B., Shreveport, La.
McDonough, William D. Pearl River, N. Y.
McDuffie, Roy O., Cincinnati, Ohio
McElhatton, Francis J. Kansas City, Mo.
McElroy, Charles R. Buffalo, N. Y.
McEwen, Cecil R. Paducah, Ky.
McFarland, Rolland, Jr. Chicago, Ill.
†McGary, S. U. Houston, Tex.
*McGeary, Frank L. New Kensington, Pa.
McGee, Herbert S. Evanston, Ill.
†McGee, W. C. Houston, Tex.
*McGlothlin, Bruce H., Jr. Buffalo, N. Y.
McGrath, Martin H. Perth Amboy, N. J.
McIlrath, Samuel W. Painesville, Ohio
McIntosh, Russell W. Maywood, Calif.
†McIntyre, G. H., Cleveland, Ohio
McKain, George D., Louisville, Ky.
McKee, Arvil B. New Kensington, Pa.
McKenney, Warren E. Houston, Tex.
McKenzie, T. Curtis Dearborn, Mich.
McKinney, T. Burns, Midland, Tex.
McKirryher, Martin J. New York, N. Y.
McLaren, Francis D. Syracuse, N. Y.
McLaren, James Oakridge, Tenn.
McMahon, George F., Chicago, Ill.
McManus, John J. Edgewater, N. J.
McMillan, W. A., Jr. Lake Charles, La.
McMullin, H. L. Dallas, Tex.
McNamara, Ambrose J. New York, N. Y.
McNamara, R. L. Haysville, Pa.
McNeil, Edwin B. Baton Rouge, La.
McNeill, John J. Melrose Park, Ill.
McNulty, Frank E. Tulsa, Okla.
McPherson, John L. Pittsburgh, Pa.
McRaven, C. H., Cocoli, Canal Zone
McSparran, W. G. Los Angeles, Calif.
†McWaters, Raymond J. Long Island City, N. Y.
McWhorter, Sam B. Plainfield, N. J.
Mead, William J. Elkhart, Ind.
Meader, Raymond B., Boston, Mass.
Means, Ben H. Houston, Tex.
Meany, John J., Jr. Linden, N. J.
Mears, Robert B., Pittsburgh, Pa.
Meek, J. Gordon Dallas, Tex.
Meglemre, Robert W. Bessemer, Ala.
Meier, Alfred O., New York, N. Y.
Meigs, W. H., Oklahoma City, Okla.
Menaul, Paul Tulsa, Okla.
Mendive, Anthony J. Houston, Tex.
Mendizza, August Murray Hill, N. J.
Mengel, Arthur C. Schenectady, N. Y.
Mensch, Harold F. Chicago, Ill.
Mensch, Ralph G. Chicago, Ill.
Mercer, C. L. Houston, Tex.
Merrill, Harry E., Buffalo, N. Y.
Merrill, Timothy W. New York, N. Y.
Merwin, Walter J. Cedar Lake, Ind.
Meserve, Ralph H., St. Paul, Minn.
Messick, W. E. Santa Fe Springs, Calif.
Metzger, Paul D., Pittsburgh, Pa.
Meyer, B. W. Oklahoma City, Okla.

Meyer, Frederick R. ..... New Haven, Conn.
†Meyer, Philip A., New York, N. Y.
†Meyer, Walter ..... St. Louis, Mo.
Michael, Lewis E. ..... Dayton, Ohio
Michaud, M. L., Los Angeles, Calif.
Mickelson, Alfred O. ..... Stonington, Mich.
Mikesell, William H., Chicago, Ill.
Miles, John A., New York, N. Y.
†Millar, Maury ..... San Francisco, Calif.
Miller, Carl F., Jr. ..... Philadelphia, Pa.
Miller, Charles E., Milwaukee, Wis.
Miller, Donald Norman ..... Los Angeles, Calif.
Miller, Dwight L. ..... Wyandotte, Mich.
Miller, Eldon F., New York, N. Y.
Miller, Harry J. ..... Dallas, Tex.
Miller, Howard C. ..... Grand Saline, Tex.
Miller, John J. ..... Pittsburgh, Pa.
†Miller, M. C. ..... West Englewood, N. J.
†Miller, Pat H. ..... Shreveport, La.
Miller, Paul Thomas, Houston, Tex.
†Miller Ralph D., Pittsburg, Kan.
Miller, Ross T. ..... Emeryville, Calif.
†Miller, W. J. ..... Chicago, Ill.
Milling, Dan J. ..... Houston, Tex.
Mills, E. J. ..... Snyder, Tex.
Mills, George A. ..... Dixon, Ill.
Mills, James L. ..... Oil City, Pa.
Mills, Lester D., Jr. ..... Cleveland, Ohio
Mills, Richard P. ..... Freedom, Pa.
Mills, Walter W., Bakersfield, Calif.
†Millsop, T. E. ..... Weirton, W. Va.
Miltenberger, Gustave ..... New Orleans, La.
Miltner, Donald E., Wichita, Kan.
Minnick, Arvel L., Shawnee, Okla.
Minor, Alton P. ..... Jackson, Miss.
Minter, James F. ..... Donaldsonville, La.
Misch, Robert D. ..... Whiting, Ind.
Mitchell, E. B. ..... Houston, Tex.
Mitchell, Francis H. ..... Los Angeles, Calif.
Mitchell, Frank K. ..... New York, N. Y.
*Mitchell, Leo S. ..... New Orleans, La.
Mitchell, Malcolm ..... Indianapolis, Ind.
Mitchell, Marvin G. ..... Atlanta, Ga.
†Mitchell, N. W., Waterbury, Conn.
Mitchell, Richard E. ..... New Orleans, La.
Mixer, Richard A. ..... Philadelphia, Pa.
Mobley, Garner C., Savannah, Ga.
*Mock, Guy C. ..... Houston, Tex.
Moehrl, Kenneth E. ..... Memphis, Tenn.
Moffatt, Thomas S., Jr. ..... Corpus Christi, Tex.
Moffett, J. L. ..... Lima, Ohio
Moffitt, John H. ..... Wichita Falls, Tex.
Mohler, Richard W. ..... Pittsburgh, Pa.
Mohr, Bernard H. ..... Chiswick, London, Eng.
Molcar, Charles P. ..... Chicago, Ill.
Moller, John H., Emeryville, Calif.
Molnar, Eric G. ..... Caracas, Venezuela
Momoi, James ..... South Milwaukee, Wis.
Moncrief, R. S. ..... Shreveport, La.
Monson, Louis T. ..... Los Angeles, Calif.
Montague, Donald E., Houston, Tex.
Montel, Joseph I., Jamaica, N. Y.
Montgomery, Allen M. ..... Cleveland, Ohio
Montgomery, Clyde W. ..... St. Louis, Mo.
Montgomery, Paul, Lafayette, La.
Montgomery, Wayne C. ..... New Orleans, La.
Moore, Albert E., Camden, N. J.
*Moore, Earl D. ..... Dallas, Tex.
Moore, Jack M. ..... Midland, Tex.
Moore, Laban T., Catlettsburg, Ky.
Moore, Orville E. ..... Zionsville, Ind.
Moore, Roy W. ..... Brooklyn, N. Y.
†Moorman, Earl F. ..... Chicago, Ill.
Moran, W. T. ..... Houston, Tex.
Morcom, Robert S., New Iberia, La.
Morgan, C. L. ..... Houston, Tex.
Morgan, T. A. ..... Houston, Tex.
Morgan, Zane V. ..... Seguin, Tex.
Mori, John Y. ..... Chicago, Ill.
Morris, Clarence S. ..... Los Angeles, Calif.
Morris, H. E. ..... Texas City, Tex.
Morris, James F. ..... Chicago, Ill.
Morrison, Barclay ..... Union, N. J.
Morrison, D. B. ..... Gary, Ind.
Morrison, John G. ..... Philadelphia, Pa.
Morrow, Hal Pat ..... Dallas, Tex.
Morrow, Orville E. ..... San Francisco, Calif.
Morse, Arley Edwin ..... Coloma, Mich.
†Morse, Robert E. ..... New York, N. Y.
Morton, Byron B. ..... New York, N. Y.
Morton, David F., Birmingham, Ala.
Moseley, E. L. ..... Houston, Tex.
Mosher, Malcolm ..... Quincy, Mass.
Mosier, Benjamin, Fort Worth, Tex.
Moss, Charles F., Jr. ..... Wilmington, Del.
Mount, W. R. ..... Edmonton, Alberta, Canada
Moyar, Robert E. ..... Sumatra, Indonesia
Moyer, Fred ..... Chicago, Ill.
Moyle, M. W. ..... Rosita, Coahuila, Mexico
Mudd, O. C. ..... Houston, Tex.
Muehlhause, Edwin H., Dallas, Tex.
Muery, Sam J., Jr. ..... Port Sulphur, La.
Mulcair, Jeremiah J. ..... New York, N. Y.
Mulheran, Bernard C. ..... Cleveland, Ohio
Muller, Herman, Jr. ..... New York, N. Y.
Mullin, Grover E. ..... Philadelphia, Pa.
Mullins, John D. ..... Houston, Tex.
Mullins, Sidney O. ..... Gary, Ind.
Mundt, H. W. ..... Diablo Heights, Canal Zone
†Munger, C. G., South Gate, Calif.
Munro, John David ..... Scotch Plains, N. J.
Munroe, D. D. ..... Oakmont, Pa.
Murphy, Arthur N. ..... London W., England
Murphy, Ashley T. ..... Los Angeles, Calif.
Murphy, G. J. W. ..... Bellaire, Tex.
Murray, Christopher A. ..... Nederland, Tex.
Murrey, O. E. ..... Tulsa, Okla.
Muschenheim, Harry, Jr. ..... Philadelphia, Pa.
Myers, G. Frank ..... Beaumont, Tex.
†Myers, W. R. ..... Wilmington, Del.

N

Nadler, Ruben ..... Corning, N. Y.
Napack, Marvin ..... Murray Hill, N. J.
Naschke, John H. ..... Houston, Tex.
Nash, William F., Jr. ..... Alhambra, Calif.
Neal, James L. ..... Dallas, Tex.
Neal, Robert W., Fort Worth, Tex.
Neaves, Carol L. ..... Dallas, Tex.
Nee, John W., Corpus Christi, Tex.
Nee, Robert M. ..... Tulsa, Okla.
†Neher, Frank H., New York, N. Y.
Neil, Frank M. ..... Houston, Tex.
Neilon, C. R. ..... Houston, Tex.
Neipp, Howard S. ..... Kansas City, Mo.
Nelson, F. M. ..... Houston, Tex.
Nelson, Forrest W. Milwaukee, Wis.
†Nelson, Harry ..... Bartlesville, Okla.
Nelson, H. Lloyd, Burlington, N. J.
Nelson, H. M. ..... Alexandria, Va.
†Nelson, L. A., Jr. ..... Freeport, Tex.
Nelson, Loyd B. ..... Cushing, Okla.
Nelson, Otis A. ..... Houston, Tex.
Neprude, E. N., Minneapolis, Minn.
Nerhood, H. Elmer ..... Akron, Ohio
Neuhoff, Paul S. ..... Monsanto, Ill.
Nevill, Richard A. ..... Fort Worth, Tex.
Newell, I. Laird ..... Hartford, Conn.
Newell, Thomas M. ..... Odessa, Tex.
Newport, John J. ..... Freeport, Tex.
Newton, William E. ..... New Orleans, La.
†Nibley, P. P., New York, N. Y.
Nicholls, Alfred ..... Detroit, Mich.
Nicholls, P. E. ..... Galveston, Tex.
Nichols, Laurie E. ..... Bellwood, Ill.
Nichols, William D., Houston, Tex.
Nicholson, C. T. ..... Buffalo, N. Y.
†Nicholson, J. C. ..... Tulsa, Okla.
Nicholson, Jay T. ..... Los Angeles, Calif.
*Nickerson, James G. ..... Lafayette, La.
Nickle, F. Verne ..... Cleveland, Ohio
Niederloh, Earl L. ..... Minneapolis, Minn.
Nieliwocki, Louis M., Orange, Tex.
Nielsen, Claudius ..... Detroit, Mich.
Nielsen, Norman A. ..... Wilmington, Dela.
Nill, Julius H. ..... New Orleans, La.
Nilson, Wesley G., New York, N. Y.
Niwao, Jitsuo ..... Hilo, Hawaii
Nixon, James A. ..... New Haven, Conn.
Nodurft, Harry M. ..... Weatherford, Okla.
Nolan, Vincent J. ..... New York, N. Y.
Nole, Vito F. ..... Waterbury, Conn.
Noppel, E. P. ..... New York, N. Y.
Norberg, H. A. ..... Tulsa, Okla.
Norcom, George D., Red Bank, N. J.
Nord, G. L. ..... Cincinnati, Ohio
Nordquist, Howard O. ..... St. Louis, Mo.
Norris, J. M., Wichita Falls, Tex.
Norris, Richard O., Camden, N. J.
Northern, Turner P. Lafayette, La.
†Northup, M. S. ..... Linden, N. J.
Norton, Harry A., Kansas City, Mo.
Norwood, Vincent M. ..... Petrolia, Ontario, Canada
Noser, W. P. ..... Houston, Tex.
Noss, Oscar F., New York, N. Y.
Noss, Oscar F., Jr. ..... Long Beach, Calif.
Notley, Charles K., Oakland, Calif.
*Novak, George W., Jr. ..... Houston, Tex.
Novosad, Andrew, Brentwood, Mo.
Noyes, A. P. ..... Kilgore, Tex.
Nuezel, E. F. ..... Cincinnati, Ohio

O

Oates, John J., Hackensack, N. J.
Obermann, Walter ..... Leonia, N. J.
O'Brien, Harold C., Jr. ..... Blawnox, Pa.
†O'Brien, H. L. East Chicago, Ind.
O'Brien, Paul S., Baton Rouge, La.
O'Brien, Thos. W. ..... Detroit, Mich.
O'Connor, Leo, Los Angeles, Calif.
Odell, L. B. ..... Houston, Tex.
Odom, William A., Lafayette, La.
Oechsle, Robert W. ..... Philadelphia, Pa.
Ogburn, H. R. ..... Marshall, Tex.
Ogden, James A. ..... Van, Tex.
O'Keefe, John F., New York, N. Y.
O'Leary, F. J., Los Angeles, Calif.
Olive, Marion J., Shreveport, La.
Oliver, J. Paul ..... Cleveland, Ohio
Olmstead, Philip J. ..... Seneca Falls, N. Y.
Olson, G. R. ..... Shreveport, La.
Olson, Theodore ..... Alice, Tex.
O'Neil, Henry J., Jr. ..... New Castle, Del.
Oravetz, Julius A. ..... Racine, Wis.
Orchard, E. L. ..... Laredo, Tex.
Orr, George F. ..... Charleston, W. Va.
Orr, Morgan ..... Chicago, Ill.
†Osborn, G. H. ..... Houston, Tex.
Osborn, Oliver ..... Lake Jackson, Tex.
Osborne, Earl H. ..... Trenton, N. J.
Osterloh, Frederick V. ..... Freeport, Tex.
Ott, Lawrence H. ..... Altadena, Calif.
Ott, Robert J. ..... Philadelphia, Pa.
Ottolenghi, Mario L. ..... New York, N. Y.
Overly, Charles R. ..... Midland, Tex.
Owen, Bruce D. ..... Oklahoma City, Okla.
Owens, Earl O., Bartlesville, Okla.
Owens, Howell C. ..... Houston, Tex.
Oxford, W. F., Jr., Beaumont, Tex.
Oxley, George W., Elizabeth, N. J.

P

Pace, Anderson, Jr. ..... New Haven, Conn.
Padron, Felix G. Martinez ..... Havana, Cuba
Page, Glenn I. ..... Tulsa, Okla.
*Paige, Henry ..... Philadelphia, Pa.
Palmquist, William W. ..... Cleveland, Ohio
Panek, Julian R. ..... Trenton, N. J.
Pantalone, Joseph A. ..... Cleveland, Ohio
Parker, Frank Collins ..... South Charleston, W. Va.
Parker, Ivy M. ..... Bremen, Ga.
Parker, Kenneth B. ..... Philadelphia, Pa.
Parker, Leonard S. ..... San Francisco, Calif.
Parker, Marshall E., Jr. ..... Houston, Tex.
†Parker, Robert B. ..... New York, N. Y.
†Parkhill, Roy F. ..... Tulsa, Okla.
Parnell, H. S. ..... Jackson, Miss.
Parr, James M. ..... Houston, Tex.
Parr, MacGregor A. Houston, Tex.
Parran, J. Harold, Baltimore, Md.
Parrish, Worden W. ..... Olney, Ill.
Parson, Robert A. ..... Chicago, Ill.
Partington, Sydney ..... Detroit, Mich.
Patrick, George M. ..... Houston, Tex.
Patterson, Bryan ..... Salt Lake City, Utah
Patterson, Don Raymond ..... Dallas, Tex.
Patterson, M. Kingsley ..... Minneapolis, Minn.
Patton, Arthur L. ..... Long Beach, Calif.
Paul, Robert J. ..... Cincinnati, Ohio
†Paulin, Roland R. ..... Detroit, Mich.
Payne, Paul B. ..... Indianapolis, Ind.
Payne, Phil R. ..... Independence, Kan.
Payson, Peter ..... Harrison, N. J.
Payton, Victor J. ..... Chicago, Ill.
Peabody, A. W. ..... Jackson, Miss.
†Peake, David W. ..... Houston, Tex.
Pearson, E. T. ..... Maplewood, N. J.
†Pearson, J. M. Swarthmore, Pa.
Peifer, Norman P., Carnegie, Pa.
Peifer, Richard H. ..... Library, Pa.
Peirce, Walter A. ..... Racine, Wis.
Pellegrino, Frank M. ..... Philadelphia, Pa.
Pelton, Charles H. ..... Clinton, Iowa
Penland, William R., St. Louis, Mo.
Pennington, Louis E., Tulsa, Okla.
†Perkins, C. L. ..... El Paso, Tex.
Perkins, Robert L., Lafayette, La.
Perkins, Wendell L. ..... Longview, Tex.
Permar, Philip H. ..... Wilmington, Del.
†Perrault, Lewis ..... Tulsa, Okla.
Perry, Joe Reddell ..... Prairie View, Kans.
Perry, Russell I. ..... Chicago, Ill.
Peterkin, Don W. ..... Chicago, Ill.
Petersen, Charles W. Beatrice, Neb.
Petersen, Lowell W. ..... Chicago, Ill.
†Peterson, A. J. ..... Chicago, Ill.
Peterson, Erle V., Wilmington, Del.
†Peterson, F. P. ..... Corpus Christi, Tex.
Petras, George R. ..... Chicago, Ill.
†Petrov, L. A. ..... Cincinnati, Ohio
Petruschka, Max, Jerusalem, Israel
Pettibone, John S. ..... Philadelphia, Pa.
Pettibone, Robert H., Dallas, Tex.
Pettijohn, Dale S. ..... Burrton, Kan.
Petty, Ralph G. ..... Mexia, Tex.
Pettyjohn, A. R. Texas City, Tex.
Pettyjohn, E. S. ..... Chicago, Ill.
†Pfeiffer, Milton J. ..... Cincinnati, Ohio
Pfrehm, Raymond H. ..... Corpus Christi, Tex.
Phelps, Lt. Edson H., Dayton, Ohio
Phelps, Samuel C. ..... Tulsa, Okla.
Phillians, T. F., Los Angeles, Calif.
Phillips, Carroll O. ..... Beeville, Tex.
Phillips, Cecil, Jr. ..... Baytown, Tex.
Phillips, Edward J. ..... Houston, Tex.
Phillips, Edwin H. ..... Oak Park, Ill.
Phillips, James H., Alliance, Ohio
Phillips, Kenneth A. ..... East St. Louis, Ill.
Phillips, Melvyn D. ..... Montreal, Quebec, Canada
Phillips, Preston D., Jr. ..... Houston, Tex.
Phillips, William D., Chicago, Ill.
Picarazzi, Joseph J. ..... Lake Charles, La.
Pickard, W. B., Jr. ..... Houston, Tex.
Pickens, Andrew T. ..... East St. Louis, Ill.
Pickering, Harry S., Miami, Fla.
†Pickrell, David D. ..... Ranger, Tex.
Pickup, Lester R. ..... Los Angeles, Calif.
Pierce, E. K. Ted ..... Houston, Tex.
Pierce, Edgar M. ..... Boston, Mass.
Pierce, Robert R., Philadelphia, Pa.
Piercey, Alexander George Arthur, Turner Valley, Alberta, Canada
Pietrzak, Aloysius J. ..... Philadelphia, Pa.
Pike, Donald B. ..... Boston, Mass.
†Pike, Vernon B. ..... Murray Hill, N. J.
Pinkerton, Harry L. ..... Pittsburgh, Pa.
Pinner, W. L. ..... Detroit, Mich.
Pirsh, Edward A., New York, N. Y.
Pitman, Hal J., Port Arthur, Tex.
Pittman, Charles U. ..... Westfield, N. J.
Pittman, James H., Jr. ..... Odessa, Tex.
Pittman, William G. ..... Hackensack, N. J.
Place, George W. ..... New York, N. Y.
Plant, A. Morton ..... New Haven, Conn.
†Platz, E. H., Jr. ..... Lebanon, Pa.
Pliner, Leon M. ..... Shreveport, La.
Ploederl, Francis J. ..... Green Bay, Wis.
Plog, Charles B., New York, N. Y.
Plombon, J. J. Corpus Christi, Tex.
Plym, Lester M. ..... Chicago, Ill.
Poetker, Robert H. ..... Alice, Tex.
Pogacar, C. F. ..... Philadelphia, Pa.
Pokorny, Jerome J., Cleveland, Ohio
Polen, Lewis B. ..... Buffalo, N. Y.
†Polhamus, John R. ..... Corpus Christi, Tex.
Pollard, T. A. ..... Dallas, Tex.
Pollock, Carl D. ..... Seattle, Wash.
†Polston, J. R. ..... Tulsa, Okla.
Pomeroy, Richard D. ..... Pasadena, Calif.
Ponte, Leon W. ..... Harvey, La.
Pool, John L. ..... Dallas, Tex.
Poole, Charles I. ..... Lubbock, Tex.
*Poole, Robert W. ..... Houston, Tex.
Pope, Robert ..... Quakertown, Pa.

Popelar, Walter A. ..... San Diego, Calif.
Porson, Allan B., New York, N. Y.
Porter, Clell O., Montebello, Calif.
Porter, Fred B., Fort Worth, Tex.
Porter, Lew F. ..... Madison, Wis.
Post, J. H. G. ..... The Hague, Netherlands
†Potashnick, R. B. ..... Cape Girardeau, Mo.
Potts, Phillip E. ..... Dumas, Tex.
†Pourbaix, M. J. Brussells, Belgium
Powell, Cecil W. ..... Massillon, Ohio
†Powell, Edwin B., Boston, Mass.
Powell, Sheppard T., Baltimore, Md.
Power, Pierce H. ..... Long Island City, N. Y.
Powers, Merle T. Murphysboro, Ill.
Powers, Stanley C. ..... Akron, Ohio
Powers, William J., Coatesville, Pa.
†Pracy, George W. ..... San Francisco, Calif.
†Prange, Frederick A. ..... Bartlesville, Okla.
Pratt, Ward E. ..... Harrison, N. J.
Pray, H. A. ..... Columbus, Ohio
Preece, Robert N., Southgate, Calif.
Preiser, Herman S. ..... Washington, D. C.
Prendergast, John P. ..... San Jose, Calif.
Prendergast, Philip J. ..... Cleveland, Ohio
Prescott, Joseph ..... Cleveland, Ohio
Presley, Maurice C. ..... Waterbury, Conn.
Price, F. Carr, Chicago Heights, Ill.
Price, Walter J. ..... Houston, Tex.
Priestley, Henry L. ..... New York, N. Y.
Prime, Joseph B., Jr., Miami, Fla.
†Prince, Arthur E. ..... New York, N. Y.
Prine, Walter H. ..... New York, N. Y.
Prior, Joseph E. ..... Mantua, N. J.
Procter, Bryant S., Jr. ..... Cleveland, Ohio
Proctor, B. L., Corpus Christi, Tex.
*Proskowitz, Seymour, Bronx, N. Y.
Prosser, Robert A. ..... Chicago, Ill.
†Prutton, C. F. ..... Baltimore, Md.
Puckett, George J., Pittsburg, Calif.
†Purdy, D. F., Los Angeles, Calif.
Purdy, George E. ..... St. Louis, Mo.
Pursell, Walter L., El Dorado, Kan.
Purton, T. A., Salt Lake City, Utah
Putnam, J. Frank ..... Atlanta, Ga.
†Pyeatt, F. E., Jr. ..... Tulsa, Okla.
Pyles, Russell ..... Olean, N. Y.
Pyott, William T. ..... Calgary, Alberta, Canada

Q

Quale, James D. ..... Pittsburgh, Pa.
Quimby, W. S., New York, N. Y.
Quinlan, Joseph Francis ..... Schnectady, N. Y.
*Quinn, John A. ..... Houston, Tex.

R

Raasch, Dallas G., La Mesa, Calif.
Radcliffe, Thomas D., Evanston, Ill.
Radovich, Frank ..... North Hollywood, Calif.
Rafsnider, Lowell B. ..... Columbus, Ohio
Raifsnider, Philip J. ..... Emeryville, Calif.
†Raigorodsky, Paul M., Dallas, Tex.
Rainey, John B. ..... Houston, Tex.
Raithel, Edward E., Pittsburgh, Pa.
Rambaldi, Elio ..... Naples, Italy
Ramsay, Clayton W. ..... Bloomington, Ill.
Range, E. C. ..... Atlanta, Ga.
Rankin, Elbert L. ..... Corpus Christi, Tex.
Ransom, R. A., Washington, D. C.
†Ranta, Leo G. ..... Chicago, Ill.
Raphael, William ..... Boston, Mass.
Rapp, Harry E. ..... Pittsburgh, Pa.
Rasmussen, Laurence M. ..... Bridgeport, Conn.
Rasmussen, V. L., St. Louis, Mo.
Rasor, John P., San Gabriel, Calif.
Rateree, James A. ..... Irving, Tex.
Ray, Edward B. ..... Midland, Tex.
Rayner, Reid L. ..... Detroit, Mich.
Read, Harold J., State College, Pa.
Reading, Robert E. ..... Dallas, Tex.
Rector, Paul F. ..... Houston, Tex.
Reeb, Fred C., Corpus Christi, Tex.
Reed, Clyde L. ..... Chicago, Ill.
Reed, C. Espey, New Orleans, La.
Reed, John W. ..... Ferndale, Mich.
Reed, Paul S. ..... Tulsa, Okla.
Reed, Ramsey M. ..... Birmingham, Ala.
Reeves, B. M. ..... Denton, Tex.
Reichard, Edmund C. ..... Holmdel, N. J.
Reid, James B., New York, N. Y.
†Reid, J. C. ..... Dallas, Tex.
Reid, Keith K., East St. Louis, Ill.
Reinhard, Herbert W. ..... Newtonville, Mass.
Reinhardt, G. A., Youngstown, Ohio
†Reinhardt, William ..... Los Angeles, Calif.
Reinhart, Fred M. ..... Silver Springs, Md.
Reinitz, B. B. ..... Patterson, N. J.
Rench, Joseph E., Jr. ..... Houston, Tex.
†Renshaw, William G. ..... Brackenridge, Pa.
Reys, John ..... Solon, Ohio
Rhoades, Ronald S. ..... New York, N. Y.
Rhodes, Edmund O. Pittsburgh, Pa.
Rhodes, H. A. ..... Houston, Tex.
Riall, Lindsey W. Shreveport, La.
Rice, Edward F. T. ..... Washington, D. C.
Rice, E. L. ..... St. Louis, Mo.
Rice, Francis T. ..... Chicago, Ill.
Rice, Gerald B. Bridgeport, Conn.
Rice, R. J. ..... Houston, Tex.
†Rich, Newton D. ..... Chicago, Ill.
Richard, Charles S. ..... North Plainfield, N. J.
†Richards, S. L., Jr. Houston, Tex.
*Richardson, James L. ..... Houston, Tex.
Richardson, John I. ..... South Gate, Calif.
Richey, Vernon T. ..... Lafayette, La.
Rickert, Herbert B. St. Louis, Mich.
Ricksecker, Ralph E. ..... Cleveland, Ohio
Riddick, Thomas M. ..... New York, N. Y.
Riddle, H. S. ..... Charleston, W. Va.
Ridenour, Charles A. ..... Beaumont, Tex.
Ridout, Robert P. San Pedro, Calif.
Riegel, G. M. ..... Massillon, Ohio
Ries, William J. ..... St. Louis, Mo.
Rifenburgh, Arthur W. ..... St. Louis, Mo.
Rigo, Jane H. M. ..... Cleveland, Ohio
Riha Robert ..... Manitowoc, Wis.
Riley, Robert F. ..... Miami, Fla.
Rimbach, Richard ..... Pittsburgh, Pa.
Rimbault, E. L., Jr. ..... New York, N. Y.
Ringer, Francis ..... Bala-Cynwyd, Pa.
Rio, Anthony J. ..... Chicago, Ill.
Rion, W. C., Jr. ..... Augusta, Ga.
Riordan, Maurice A. Houston, Tex.
†Riordan, M. B. Los Angeles, Calif.
Riseling, T. M. ..... Tulsa, Okla.
Risetter, Leonard O. Chicago, Ill.
Ritchie, Robert Trinidad, B. W. I.
Robb, Edward H. ..... Buffalo, N. Y.
Robbins, John T. New York, N. Y.
Robbins, Kenneth W. Houston, Tex.
Roberson, Frank ..... Gary, Ind.
Roberti, Giorgio ..... Rome, Italy
Roberts, John K. ..... Pittsburgh, Pa.
Roberts, John P. ..... Norman, Okla.
Roberts, L. J. ..... Amarillo, Tex.
Roberts, R. G. ..... Chicago, Ill.
Robertson, Oliver W. ..... Somerville, Mass.
Robeson, Ralph M. ..... Los Angeles, Calif.
Robinson, Bruce A. ..... Vancouver, B. C., Canada
Robinson, Harold A. Midland, Mich.
Robinson, Henry B. ..... Brooklyn, N. Y.
Robinson, John L. Midland, Mich.
Robinson, Robert M. ..... Great Bend, Kan.
Robinson, T. J. ..... Houston, Tex.
Robinson, Vincent D. ..... New York, N. Y.
Robinson, William Witten, Jr. ..... Los Angeles, Calif.
Robison, Walter L. Cleveland, Ohio
Robson, Arthur D. ..... Staten Island, N. Y.
†Roddey, O. C. ..... Monroe, La.
Roden, Harry ..... Port Neches, Tex.
Rodgers, Calvin ..... Tulsa, Okla.
Rodgers, James W. Lafayette, La.
Rodgers, John ..... Tulsa, Okla.
Roeder, George F. ..... Buffalo, N. Y.
*Roesler, Bernard R. ..... Rosenberg, Tex.
†Roesler, Ewald A. Houston, Tex.
Roessing, Earl F. ..... Napoleon, Ohio
Rogers, Harold G. ..... New York, N. Y.
Rogers, Harry D. ..... Dayton, Ohio
Rogers, James F. ..... Mantua, Ohio
Rogers, John A. ..... Tulsa, Okla.
Rogers, Oscar F. ..... Waukegan, Ill.
Rogers, Philip S. Lockport, N. Y.
Rogers, R. R. ..... Ottawa, Ontario, Canada
†Rogers, Walter F. Houston, Tex.
†Rogerson, J. B. El Dorado, Ark.
Rohrman, F. A. ..... Boulder, Colo.
Rohrman, Robert W. ..... Maplewood, La.
Rohwedder, John L. ..... Rock Island, Ill.
Rolfes, Richard P. Cincinnati, Ohio
Roll, Kempton H. New York, N. Y.
Romell, Robert F. Cincinnati, Ohio
Romig, O. E. ..... Pittsburgh, Pa.
Ronan, Richard J. ..... Los Angeles, Calif.
Rondeau, H. S. ..... Shaker Heights, Ohio
Roosa, Max B. ..... Detroit, Mich.
Root, Wesley B. Baton Rouge, La.
Rose, Gordon P., Sr. Detroit, Mich.
Rose, Phillip E. ..... Chicago, Ill.
†Rose, W. A. ..... Houston, Tex.
Rose, W. T. ..... Chicago, Ill.
Rosenthal, Morris Alexandria, Va.
Ross, Anthony ..... Youngstown, Ohio
Ross, Culbertson, W. ..... Washington, D. C.
Ross, Kenneth B. London, England
Ross, Sterling L. ..... Arlington Heights, Ill.
Rosselle, Douglass T. Miami, Fla.
Rosson, J. H., Jr. ..... Corpus Christi, Tex.
†Rothrock, E. S. ..... Houston, Tex.
Rouland, E. E. ..... Granite City, Ill.
Routson, L. B. ..... Cincinnati, Ohio
†Rowe, Hartley ..... Boston, Mass.
Royston, John H. ..... Blawnox, Pa.
Royston, Louis G. ..... Blawnox, Pa.
Royston, Thos. T. ..... Blawnox, Pa.
Rozelle, W. W. ..... Salt Lake City, Utah
Rudolf, Henry T. Jacksonville, Fla.
Rue, Edward C. ..... Boston, Mass.
Ruffing, Frank M. Trenton, Ohio
Runser, Skyles E., Jr. ..... Detroit, Mich.
Rupf, J. Albert ..... Wichita, Kan.
Rupp, Earl V. ..... Chicago, Ill.
Rush, E. H. ..... East Chicago, Ind.
Russell, G. I. ..... Chatham, Ontario, Canada
Russell, John C. Albuquerque, N. M.
Rutemiller, Herbert C. ..... Cleveland, Ohio
Rutherford, John J. B. ..... Beaver Falls, Pa.
Rutledge, Collie C., Jr. ..... Shreveport, La.
Rutter, Charles M., Jr. ..... Pittsburgh, Pa.
Rydell, Robert G. ..... Chicago, Ill.
†Ryznar, J. W. ..... Chicago, Ill.

S

Sadoulet, Maurice ..... Lyon, Rhone, France
*Saia, Anthony ..... Houston, Tex.
†Saigh, N. A. ..... San Antonio, Tex.
Salle, William H. ..... Chicago, Ill.
Salmon, Philip A. Newark, N. J.
Sample, Clarence H. ..... New York, N. Y.
Sampson, Stephen Symon ..... Houston, Tex.
Sandberg, Paul A. ..... Cicero, Ill.
Sandborg, Ogden W. Chicago, Ill.
Sandel, Walter J. Lakewood, Ohio
Sanders, Irvin C. ..... Independence, Kan.
Sanders, W. S., Jr. ..... Washington, D. C.
Sanderson, Wiley D. Detroit, Mich.
Sandor, John G. ..... Cleveland, Ohio
†Sands, George A. ..... New York, N. Y.
Sanford, Robert D. St. Louis, Mo.
Sargant, B. L. ..... London, Ontario, Canada
Sargent, John E. ..... Tulsa, Okla.
Satz, Leo H. ..... Schenectadv, N. Y.
Saulson, Saul ..... Detroit, Mich.
Saunders, William F. ..... Maywood, Calif.
Savage, Robert H. ..... Los Angeles, Calif.
Saye, Hugh A., Jr. Houston, Tex.
Scamman, Chas. W. Houston, Tex.
Scanlon, D. A. ..... Cleveland, Ohio
Scarola, V. J. ..... New York, N. Y.
Scarpa, Oscar ..... Milan, Italy
Schaefer, Leonard P. Detroit, Mich.
Schaefer, Ralph A. Cleveland, Ohio
Schaller, Charles C. ..... New Orelans, La.
Schauers, Joseph A. ..... Philadelphia, Pa.
Scheil, Merrill A. Milwaukee, Wis.
†Scherer, Lewis F. Houston, Tex.
Schereschewsky, P. L. ..... Paris, France
Schermer, Richard ..... Dayton, Ohio
Schick, William F., Jr. ..... Tulsa, Okla.
Schiff, Melvin J. Newark, N. J.
Schiffer, Jacques M. ..... New York, N. Y.
Schilling, W. M. ..... Bell, Calif.
Schlather, Max F. ..... San Antonio, Tex.
Schlaudt, Clarence A. Trona, Calif.
Schleicher, Martin E. Buffalo, N. Y.
Schlossberg, Louis ..... Conshohocken, Pa.
Schlueter, August New York, N. Y.
Schmeeckle, Duane A. ..... Donaldsonville, La.
Schmid, Charles F. Seymour, Conn.
Schmidt, Burton J. ..... Wilmette, Ill.
Schmidt, Fred A. ..... Houston, Tex.
Schmidt, Herbert W. ..... Midland, Mich.
Schmidt, R. W. Lake Jackson, Tex.
Schmidt, R. W. Sierra Madre, Calif.
†Schmierer, A. F. ..... Beatrice, Neb.
Schmitz, Carl Edward Chicago, Ill.
Schmitz, Fred W. Terre Haute, Ind.
Schmuck, G. Gordon Chicago, Ill.
Schmuck, Howard K., Jr. ..... Houston, Tex.
Schneider, Frederick W. ..... Woodhaven, N. Y.
Schneider, John H. ..... Whitefish Bay, Wis.
†Schneider, William R. ..... Emeryville, Calif.
Schofer, Nathan, New York, N. Y.
Schofield, Cecil ..... Cleveland, Ohio
Schor, Milton ..... Chester, Pa.
Schreiner, William J. ..... Cincinnati, Ohio
Schreitz, William Gordon ..... Annapolis, Md.
Schroeder, Clarence E. ..... Milwaukee, Wis.
Schroth, Charles R. ..... Haddon Heights, N. J.
Schroth, Harry A. ..... Glendive, Mont.
Schueler, Robert C. ..... Bishop, Tex.
†Schuh, A. E. ..... Burlington, N. J.
Schuhmacher, Gordon S. ..... South Gate, Calif.
†Schultz, R. F. ..... Wilmington, Del.
Schupp, Carleton H. Westwego, La.
Schustack, Edward H. ..... Huntington Park, Calif.
Schutt, Russell W. Franklin, La.
Schwab, Carl M. ..... New Iberia, La.
Schwalm, Lawrence H. ..... Cleveland, Ohio
Scott, F. L. ..... Carteret, N. J.
Scott, Gordon N. ..... Los Angeles, Calif.
Scott, Harold H. ..... Martinez, Calif.
Scott, John B. ..... Pasadena, Tex.
Scott, Paul T. ..... Fort Worth, Tex.
Scott, T. C. ..... Kokomo, Ind.
Scott, Thomas W. ..... Odessa, Tex.
Scribner, Leonard ..... Lake Bluff, Ill.
Scull, William L. ..... Colorado Springs, Colo.
Seagren, G. W. ..... Pittsburgh, Pa.
Seal, Reed E. ..... Lakewood, Ohio
Seal, William D. Indianapolis, Ind.
Seaman, E. Eugene Wharton, N. J.
Searcy, John E., Jr. ..... Cabimas, Zulia, Venezuela
Searer, Jay C. ..... North Tonawanda, N. Y.
Secrest, Leslie C. Ponca City, Okla.
†Sedgeman, W. H. ..... Toledo, Ohio
Segel, Kalman ..... Aruba, Netherlands West Indies
Seidel, G. E. ..... Chicago, Ill.
Seidenstricker, R. A. ..... Milwaukee, Wis.
Seidman, Stanley M. ..... Cleveland, Ohio
Seifried, Dean B. ..... Spring Valley, N. Y.
Selle, Joseph B. ..... Houston, Tex.
Sellers, William N. ..... Elizabethton, Tenn.
†Senatoroff, N. K. ..... Los Angeles, Calif.
Serbula, Steve, Jr. ..... Chicago, Ill.
Serenco, Harvey ..... St. Louis, Mo.
Serven, Edward J., Jr. ..... Clifton, N. J.
Severance, Wesley A. ..... Cleveland, Ohio
Sevin, Lloyd L. New Orleans, La.
Sexton, Earl M. ..... Toledo, Ohio
Seyl, Robert G. ..... Evanston, Ill.
Seymour, Arthur H. ..... Argo, Ill.
†Seymour, Raymond B. ..... Mertztown, Pa.
Shackleford, Robert E. Tulsa, Okla.
†Shanahan, J. P. ..... St. Louis, Mo.
Shankweiler, Fred K. ..... Wilmington, Del.
Shapiro, Myer ..... Boston, Mass.
Share, Martin ..... Chicago, Ill.
Sharpe, L. G. ..... Houston, Tex.
Sharpnack, E. V. ..... Louisville, Ky.
Shaw, A. G. ..... New York, N. Y.
Shaw, George E. ..... Houston, Tex.
Shaw, George Kendall ..... New York, N. Y.
Shaw, George S. ..... Shawinigan Falls, P. Q., Canada
Shaw, William E. ..... Cincinnati, Ohio
Sheard, Walter G., Jr. ..... Freeport, N. Y.
Sheets, Macon ..... Corpus Christi, Tex.
Sheffer, James W. ..... Philadelphia, Pa.
Sheldahl, David B. ..... Harvey, Ill.
Shellenbarger, Wilbur D. ..... Toledo, Ohio
Shelton, M. J. ..... La Mesa, Calif.
*Shelves, Arthur R. ..... Chicago, Ill.

Shemilt, Leslie W. ..... Vancouver, Canada
Shenton, F. George ..... Monroeville, N. J.
Shepard, Arthur P. Flushing, N. Y.
Shepard, E. R. Washington, D. C.
Shepard, Harry L. Houston, Tex.
Shepard, Spencer W. ..... New York, N. Y.
Sheppard, Joseph E. ..... Cleveland, Ohio
Sheppard, Lyle R. Houston, Tex.
Sherer, Clayton M. Holtwood, Pa.
Sherman, Charles H. Akron, Ohio
Sherwood, B. C. Chicago, Ill.
Sherwood, William C. ..... South Boston, Mass.
Shideler, Norman T. ..... Allison Park, Pa.
Shields, Morton K. Van Nuys, Calif.
Shier, Mannith Jersey City, N. J.
Shigeno, Hayata Tokyo, Japan
Shigley, C. M. Freeport, Tex.
Shipman, Waldo A. ..... Falls Church, Va.
Shipps, Arthur W. Oakland, Calif.
Shnidman, Louis Rochester, N. Y.
Shoan, Raymond A. Chicago, Ill.
Shobe, E. H. Corpus Christi, Tex.
Shobe, O. F. Cleveland, Ohio
Shock, D. A. Ponca City, Okla.
Shoemaker, Raymond T. ..... Dallas, Tex.
Shonafelt, Austin E. ..... Bakersfield, Calif.
Shoop, John W. Cleveland, Ohio
Shoor, Abraham Haifa, Israel
Short, Howard E. Cincinnati, Ohio
Shoumatoff, Nicholas ..... New York, N. Y.
Shuldener, Henry L. ..... New York, N. Y.
Shupp, Carl W. Glendale, Calif.
Shultz, S. T. ..... Ras El Mishaab, Saudi Arabia
Sibley, Robert S. St. Louis, Mo.
Siddall, D. F. Akron, Ohio
Sidwell, C. V. Tulsa, Okla.
Siebert, C. A. Ann Arbor, Mich.
Siegel, Edward S. Baldwin, N. Y.
*Silberstein, Milton L. ..... Houston, Tex.
Silkworth, George H. ..... New York, N. Y.
Sill, George H. Philadelphia, Pa.
Sills, T. O. Kannapolis, N. C.
Sime, Robert M. Washington, D. C.
Simmons, Edward E., Jr. ..... Pasadena, Calif.
Simmons, Julius M. Chicago, Ill.
Simmons, William P. ..... San Francisco, Calif.
Simon, Allan Harrison, N. J.
Simons, Gordon F. Reading, Pa.
Simpson, A. D., Jr. Houston, Tex.
Simpson, John B. Jackson, Mich.
Simpson, N. H. Fort Worth, Tex.
Sims, C. I. Dallas, Tex.
*Sims, Lt. Chester T. ..... Ft. G. G. Meade, Md.
Sims, John J. Canyon, Tex.
Skafte, Stanley F. Arcadia, Calif.
Skeie, Kermit Chicago, Ill.
Skinner, Edmond N., Jr. ..... New York, N. Y.
Skinner, S. D. Buffalo, N. Y.
†Skog, Ludwig, Jr. Chicago, Ill.
Slavik, Edward W. ..... Corpus Christi, Tex.
†Sline, Louis L. Houston, Tex.
Slonek, Otto F. Houston, Tex.
†Slough, Ralph M. Findlay, Ohio
Slover, Charles L. Dallas, Tex.
Small, Charles Sydney ..... New York, N. Y.
Smith, Adrian W. ..... San Francisco, Calif.
Smith, Alonzo L. Houston, Tex.
Smith, Alvis F. Minneapolis, Minn.
Smith, Arthur B. Jacksonville, Fla.
Smith, Bertram M. ..... Los Angeles, Calif.
Smith, Carl B. Chicago, Ill.
Smith, Carl M. Houston, Tex.
Smith, Clair J. Bakersfield, Calif.
Smith, Clarence W. ..... Philadelphia, Pa.
Smith, Claude B. ..... San Francisco, Calif.
Smith, C. W. Crossett, Ark.
Smith, Don C. Port Arthur, Tex.
Smith, H. D. ..... Halifax, N. S., Canada
Smith, Harold L. Kansas City, Mo.
Smith, James New York, N. Y.
Smith, James M. Shreveport, La.
Smith, Joseph W. Chicago, Ill.
Smith, Lyle R. Ogallala, Neb.
Smith, Martin B. Pasadena, Calif.
Smith, Nowery J. Houston, Tex.
†Smith, O. R. Fort Worth, Tex.
Smith, Philip H. St. Louis, Mo.
Smith, Randal E. Carlsbad, N. M.
†Smith, Rex L. Tulsa, Okla.
Smith, Robert J. Chicago, Ill.
Smith, Robert M. Houston, Tex.
Smith, Roy B. Erwinna P. O., Pa.
Smith, Sydney S. New York, N. Y.
Smith, Sidney V. Houston, Tex.
Smith, Tracy E. Dallas, Tex.
†Smith, Turner C. ..... Los Angeles, Calif.
Smith, Vaughn R. Richmond, Calif.
Smith, Vernon R. Massillon, Ohio
Smith, Walter R. Buffalo, N. Y.
Smith, William A. Brunswick, Ga.
Smith, William B., Jr. ..... Shreveport, La.
Smith, William E., Jr. ..... Cleveland, Ohio
Smith, William Furber ..... Hoboken, N. J.
Smith, William N. Peru, Ill.
Smith, Winston G. Houston, Tex.
Snashall, Earl H. Columbus, Ohio
Snedaker, Delbert G. Houston, Tex.
Snell, Clark A. New York, N. Y.
Snider, Henry I. ..... South Gate, Calif.
†Snyder, B. W. ..... Calgary, Alberta, Canada
Snyder, Fred B. Alliance, Ohio
Snyder, Frederick Joseph ..... Northridge, Calif.
Snyder, Kenneth T. Houston, Tex.
Snyder, Louis A. ..... Wilmington, Calif.
Soley, R. Clyne Cambridge, Mass.
Sosnin, H. A. Jenkintown, Pa.
Spafford, Perry Parker ..... Houston, Tex.
Spalding, Donald A. Midland, Mich.
Spalding, James C., Jr. Dallas, Tex.
Spangenberg, Robert F. ..... West Allis, Wis.
Sparks, Lt. Comdr. Robert E. ..... Denver, Colo.
Sparrow, Lionel R. Homs, Syria
Spector, Dov. Tel Aviv, Israel
Speller, Frank N. Pittsburgh, Pa.
†Spencer, S. E. Philadelphia, Pa.
Spinks, Lee N. Shreveport, La.
Spoehr, Thomas F. ..... Morton Grove, Ill.
Spooner, Leonard G., Jr. ..... Carteret, N. J.
Sprague, E. Richard ..... Compton, Calif.
Spraul, J. Robert ..... East Chicago, Ind.
Sprowles, Donald O. ..... New Kensington, Pa.
Stafford, Allen D. Houston, Tex.
Stafford, Jay D. Odessa, Tex.
Stalker, Marion H. ..... Los Angeles, Calif.
Stanley, Alfred H. Chicago, Ill.
Stanton, W. L. Shreveport, La.
Staples, William R. Union, N. J.
Starbird, L. C. Dallas, Tex.
Stark, Conrad Wellsville, N. Y.
Statham, Tom R. Dallas, Tex.
Stauffacher, E. R. ..... Los Angeles, Calif.
†Stearns, D. E. Shreveport, La.
Stearns, Kendall P. Pittsburgh, Pa.
Stearns, Ned C. Shreveport, La.
Steel, Edward W. Pittsburgh, Pa.
Steele, C. Jay Atlanta, Ga.
Steffens, Martin L. ..... Oklahoma City, Okla.
Stegner, A. L. Houston, Tex.
Stein, Walter F. G. Pampa, Tex.
Steinberger, Chester Houston, Tex.
Steiner, Robert H. Mertztown, Pa.
Stelzer, James G. Jackson, Mich.
Stephan, Dean E. ..... Los Angeles, Calif.
Stephens, E. H. Wichita, Kan.
Stephens, Foster M. ..... Los Angeles, Calif.
Stephens, Robert A. Easton, Pa.
Stephens, Thomas O. Dallas, Tex.
Stephens, William H. ..... Irvington, N. J.
Stephenson, G. W. ..... Corpus Christi, Tex.
Stephenson, James F. ..... Houston, Tex.
Stephenson, R. B. Dayton, Ohio
†Stepp, V. E. Dallas, Tex.
Stericker, William ..... Upper Darby, Pa.
*Stern, Milton Cambridge, Mass.
Sterne, Cecil M. ..... Long Island City, N. Y.
Sterrett, Elton Houston, Tex.
Stetson, Richard W. ..... New York, N. Y.
Stevens, Chapin E. ..... New York, N. Y.
Stevens, Ward W. Monroe, La.
Stevenson, John M. Dallas, Tex.
Stevenson, Kenyon, Jr. ..... Huntsville, Ala.
†Stewart, Alex New York, N. Y.
Stewart, C. A. New Orleans, La.
Stewart, Edwin L. ..... New York, N. Y.
Stewart, Isaac New York, N. Y.
Stewart, W. Fred Tulsa, Okla.
Stewart, W. H. Beaumont, Tex.
Stiers, Vernon E. Beaverton, Ore.
Stilgenbauer, N. T. Tulsa, Okla.
Stirling J. C. Tulsa, Okla.
Stitt, James R. Detroit, Mich.
†Stivers, F. A. Tulsa, Okla.
Stobaugh, Robert B., Jr. ..... Caripito, Monagas, Venezuela
†Stobbs, Henry A. ..... Wheeling, W. Va.
Stobie, John J., Jr. Chicago, Ill.
Stockdale, Harold L. Houston, Tex.
Stoddard, Edgar S. Chicago, Ill.
Stoertz, Howard Philadelphia, Pa.
Stokes, James H. Houston, Tex.
Stokes, William S. ..... Huntington Park, Calif.
*Stone, J. M. Wilmington, Del.
Storer, Alton B. ..... Kansas City, Kans.
Storm, Arthur E. Associated, Calif.
Story, E. B. Ambridge, Pa.
†Stott, Tom Morton Grove, Ill.
Strachan, John F. ..... London, England
Strader, William P. Dayton, Ohio
Strain, Marrette ..... Ridgefield Park, N. J.
†Strange, Harold T. Mobile, Ala.
Strawn, Lynn Rudolph ..... Port Neches, Tex.
Streater, Floyd E. Philadelphia, Pa.
Streep, Samuel C. Baltimore, Md.
Streever, Otis J. ..... Newport News, Va.
Streicher, Lee Laverne, Calif.
†Streit, Frank H. Columbus, Ohio
Strickland, Henry R. ..... San Francisco, Calif.
Strom, C. F. Newark, N. J.
Stromsoe, Douglas A. Azusa, Calif.
Stuart, Jack L. Dallas, Tex.
Stuart, Linden, Jr. ..... Kenilworth, N. J.
Stuart, Paul S., Jr. ..... New Orleans, La.
†Stubbs, F. J. ..... Edmonton, Alberta, Canada
Stubbs, Thomas L. ..... Montreal, Quebec, Canada
Studer, Fred R. Wilmington, Del.
†Stull, Fred D. Owensboro, Ky.
Sturrock, Murray G. ..... Pittsburgh, Pa.
Stutzman, Milo J. Kansas City, Mo.
Sudduth, Lamar F. Midland, Tex.
Sudrabin, Leon P. Newark, N. J.
Sullivan, E. H. Shreveport, La.
Sullivan, Jean H. Dallas, Tex.
Sullivan, M. N. Houston, Tex.
Sundberg, Jack O. Coalville, Utah
Sutherlin, James E. Rahway, N. J.
Sutter, Carl H. Wichita, Kan.
Suverkrop, E. A. Trenton, N. J.
Svetlik, Joseph Hammond, Ind.
Svrchek, Joseph G. Chicago, Ill.
Swanbeck, Leonard W. ..... St. Jacob, Ill.
†Swann, J. S. Hammond, Ind.
Sward, G. G. Washington, D. C.
†Swartout, C. W. St. Louis, Mo.
Sway, Boris Cincinnati, Ohio
Sweet, Warren W. ..... Jersey City, N. J.
Swensson, Stuart J. ..... Pittsburgh, Pa.
Swift, John Cambridge, Mass.
Swindoll, Robert E. Jackson, Miss.
Swope, John G., Jr. ..... Texas City, Tex.
*Sybert, Jack H. Midland, Tex.

T

Tait, Emmitte P. Atlanta, Ga.
Talbott, Daniel W. Hillside, N. J.
Talley, Royal N. ..... Los Angeles, Calif.
†Talmey, Paul Chicago, Ill.
Tamez, Oscar Vazquez ..... Tampico, Tam., Mexico
Tanaka, Michio Osaka, Japan
Tandy, Edward H. ..... El Segundo, Calif.
Tarquinee, Val New York, N. Y.
Tator, Kenneth Coraopolis, Pa.
Tatum, Joe F. Hattiesburg, Miss.
Tatum, John M. Hattiesburg, Miss.
Taubman, Louis Tulsa, Okla.
Taylor, Frank S. ..... Oklahoma City, Okla.
Taylor, Gerald D. Shreveport, La.
†Taylor, R. D. New York, N. Y.
†Taylor, R. Derrill ..... Salt Lake City, Utah
Taylor, Ritchie P. Baltimore, Md.
Taylor, Robert W. Denver, Colo.
Taylor, Walter E. Houston, Tex.
Taylor, William R. ..... Corpus Christi, Tex.
Teahan, James T. ..... Staten Island, N. Y.
Teale, Edward P. ..... Washington, D. C.
Teel, Rodney B. Wilmington, N. C.
Teeple, Herbert O. ..... New York, N. Y.
Temmerman, John A. ..... Rochester, N. Y.
Tenenbaum, Martin J. ..... Waukegan, Ill.
Terrill, J. Mark Chicago, Ill.
Terry, Fred P. Oakland, Calif.
Thalmann, E. H. ..... New York, N. Y.
Thatcher, Fred G. ..... Las Piedras Falcon, Venezuela
Thayer, Starr Houston, Tex.
Thiede, Richard Conrad ..... Grasselli, N. J.
†Thies, H. R. Akron, Ohio
†Thistle, James F. Ashland, Ky.
†Thomas, Arba Middletown, Ohio
Thomas, Beaumont ..... Watertown, N. Y.
Thomas, Paul D. New York, N. Y.
Thomas, Ralph W. Waukesha, Wis.
Thompson, Charles H. ..... Baldwin, N. Y.
Thompson, Harris Chicago, Ill.
*Thompson, James B. ..... Houston, Tex.
Thompson, John G. ..... Washington, D. C.
Thompson, Roy T. Houston, Tex.
†Thompson, R. W. Big Spring, Tex.
Thompson, Thomas F., Jr. ..... St. Petersburg, Fla.
Thomson, J. B. Big Rapids, Mich.
†Thornberg, Joseph E. ..... Niagara Falls, N. Y.
Thorne, Anthony Z. Maywood, N. J.
Thorney, Charles E., Jr. ..... Bellaire, Tex.
Thornhill, W. H. T. ..... Westfield, N. J.
Thornton, J. A., Jr. ..... Cleveland, Ohio
Thornton, William N. Dallas, Tex.
Thorpe, Vincent A. Freeport, Tex.
Tibbetts, E. F. North Quincy, Mass.
Tice, E. Allen New York, N. Y.
Tietze, I. B. Bartlesville, Okla.
Timberlake, Philip S. ..... Birmingham, Ala.
Tinney, Thomas B. ..... Philadelphia, Pa.
Tisdale, O. R. Houston, Tex.
Titsworth, Edwin J. Boston, Mass.
Titterington, Y. W. Tulsa, Okla.
Tobin, H. H. Aurora, Ill.
Todd, Raymond W., Jr. ..... Chicago, Ill.
Todhunter, Harold A. ..... Los Angeles, Calif.
Tohline, Max B. Beaumont, Tex.
Tomb, H. H. Lake Charles, La.
Tompkins, Albert H., Jr. ..... Los Angeles, Calif.
Toolan, Francis P. ..... New Orleans, La.
Toomey, Joseph C. ..... East Rochester, N. Y.
Torrans, David J. Parlin, N. J.
*Totah, Nadim Houston, Tex.
Tour, Sam New York, N. Y.
Towne, Robert L. ..... Caracas, Venezuela
Tracey, Edward J. J., Jr. ..... State College, Pa.
Tracy, Arthur W. ..... Waterbury, Conn.
Tragardh, Uno Stockholm, Sweden
Trapp, Raymond F. Hapeville, Ga.
†Treichler, H. E. Newgulf, Tex.
Treseder, Richard S. ..... Emeryville, Calif.
Trilsch, John D. Houston, Tex.
Trimbur, William ..... Clifton Heights, Pa.
Tripler, Arch B., Jr. ..... Columbus, Ohio
†Trishman, L. E. Ambridge, Pa.
Trissal, J. M. Chicago, Ill.
†Troseth, Ralph Midland, Tex.
Trouard, Sidney E. ..... New Orleans, La.
Troupe, Ralph A. Akron, Ohio
Trout, H. E., Jr. Pittsburgh, Pa.
Trueblood, Howard M. ..... Dobbs Ferry, N. Y.
Trumpour, Hermon Bidwell ..... Buffalo, N. Y.
Tschudi, Traugott ..... Long Island City, N. Y.
Tucker, Billie E. Beaumont, Tex.
Tucker, Sydney Oswego, N. Y.
Tuggle, Layton C. Pasadena, Tex.
Tuggle, Ray Lafayette, La.
Tuhy, Mirko J. Fanwood, N. J.
Tull, Walter T. Longview, Tex.
Tully, Thomas J. Rensselaer, N. Y.
Tundermann, Werner O. ..... Rahway, N. J.
Tune, Newell W. ..... Los Angeles, Calif.
Tupholme, Charles B. ..... NR. Sheffield, England
Turner, C. D. Philadelphia, Pa.
Turner, Delber W. Houston, Tex.
Turner, Elmer A. Malden, Mass.
*Turner, Guy C. Houston, Tex.
Turpin, Thomas O., Jr. ..... Independence, Kan.
Tuthill, Arthur H. Wilmington, Del.
Tweedle, Lloyd S. ..... Hamilton, Ontario, Canada
Tyler, John C., Jr. LaPorte, Tex.
Tytell, Boris H. Mattapan, Mass.

U

Uher, Joseph F. Cleveland, Ohio
Uhlig, H. H. Cambridge, Mass.
Uhr, Robert J. New Braunfels, Tex.
Ullrich, A. H. Austin, Tex.
Underwood, Charles F.
Aliquippa, Pa.
Underwood, O. G. Chicago, Ill.
Unger, Julian H. Houston, Tex.
Unger, Lewis C. Richmond, Va.
†Unruh, Earl W.
Independence, Kan.
Updegraff, Norman C.
Louisville, Ky.
Upton, Frederick P.
Washington, D. C.
Urbanek, Joseph P.
Washington, D. C.
Urian, James H. Marcus Hook, Pa.

V

Vahldieck, Nathan P.
Milwaukee, Wis.
Valdespino, Ramon Tampa, Fla.
Vance, Thomas L. Fort Worth, Tex.
†Vandaveer, F. E. Cleveland, Ohio
Van Delinder, L. S.
South Charleston, W. Va.
Vandenburgh, David G.
New Kensington, Pa.
Van Der Baan, Sj.
Las Piedras, Estado Falcon
Venezuela
Van Der Haas, Hans
Maatschappy, c/o C.O.I.M.,
Curacao, N. W. I.
†Van Der Hoeven, H.
The Hague, Netherlands
Van Der Horst, Hendrik
Olean, N. Y.
Vanderpool, Howard
Long Island City, N. Y.
Vander Valk, Christy J.
New York, N. Y.
Van Der Velde, J. C.
The Hague, Netherlands
Van De Water, Donald F.
Philadelphia, Pa.
Van Etten, Frank M.
Washington, D. C.
Vangsnes, K. T. Pasadena, Calif.
Van Horne, Roger H.
Niagara, Falls, N. Y.
Vanick, James S. New York, N. Y.
Van Iderstine, Robert
Rochester, N. Y.
Van Loo, Maurice Chicago, Ill.
Van Natta, C. A. Chicago, Ill.
Van Nouhuys, Herbert C.
Atlanta, Ga.
Van Oosterwijk, A. R. Kolff
Amsterdam, Netherlands
Van Petten, Oliver W.
Charleston, W. Va.
Van Rysselberge, Maurice
Brussels, Belgium
Van Rysselberghe, Pierre
Eugene, Ore.
†Van Vliet, R.
Staten Island, New York, N. Y.
Vaughan, Charles E., Jr.
West Monroe, La.
Vaughan, Lewis H. Alliance, Ohio
†Vaughan, Wm. H. Houston, Tex.
Vaurio, V. W. Pittsburgh, Pa.
Veneigh, Leroy J.
Oklahoma City, Okla.
Vereecke, Edwin Wm.
Cleveland, Ohio
†Verink, Ellis D., Jr.
New Kensington, Pa.
Vernooy, B. Tulsa, Okla.
Vidovic, Paul P. Baton Rouge, La.
Vielle, S. M. Swarthmore, Pa.
†Vierling, Edward C., Jr.
Pittsburgh, Pa.
Vierling, Wm. Texas City, Tex.
Vines, E. D. Woodward, Ala.
Vogel, Alfred J. Midland, Tex.
Vogel, Henry A. Milwaukee, Wis.
Vogler, Gus Lafayette, La.
*Voight, Richard A.
Port Arthur, Tex.
Volk, Kenneth Q.
Los Angeles, Calif.
Volkening, V. B. Freeport, Tex.
Vollmer, Leslie W. Pittsburgh, Pa.
Von Allmen, John
Corpus Christi, Tex.
Vondrasek, Henry W.
Brentwood, Mo.
Von Lossberg, Lewis G.
Baltimore, Md.
Von Meyer, William H.
St. Louis, Mo.
Waber, James Thomas
Los Alamos, N. M.
†Wachter, Aaron Emeryville, Calif.

W

†Wade, O. W. Houston, Tex.
Wade, Paul A. Jackson, Tenn.
Wafer, George W. Shreveport, La.
Waggoner, Verbon E.
Goodland, Kan.
Wagner, Carl Cambridge, Mass.
Wagner, Ernest F.
Burlington, N. J.
Wagner, John Jr. Philadelphia, Pa.
Wagner, R. H.
New Kensington, Pa.
Waguespack, Otis J. Lafayette, La.
Wahlquist, Hugo W.
New York, N. Y.
Wahlquist, K. D. Dallas, Tex.
Wainman, L. G. El Paso, Tex.
Wainwright, Ray M. Urbana, Ill.
Wakefield, Clarence N., Jr.
South Gate, Calif.
Walczak, M. R. New York, N. Y.
Waldie, Donald J.
Los Angeles, Calif.
Waldrip, H. E. Houston, Tex.
Waldron, Leo J. Kensington, Md.
Walker, Basil G.
Minneapolis, Minn.
Walker, H. N. College Point, N. Y.
Walker, Jack R. Shreveport, La.
Walker, James D. Marion, Ohio
Walker, Robert B. Odessa, Tex.
Wallace, E. W. Bellaire, Tex.
Wallace, Robert P.
Williamsburg, Va.
Wallace, William P.
Oklahoma City, Okla.
†Walsh, Harry W.
New York, N. Y.
Walsh, Martin P. St. Louis, Mo.
Walter, Victor A., Jr.
Natchez, Miss.
*Walters, Wally Z.
Edgeworth Sewickley, Pa.
Walters, William A. Parma, Ohio
Walther, Herbert H. Tulsa, Okla.
Walton, Charles J.
New Kensington, Pa.
Walton, Robert J., 3rd
New Providence, N. J.
Wamsley, Paul, Jr.
Baton Rouge, La.
Ward, Charles F.
Corpus Christi, Tex.
Ward, Richard R. L.
Lake Charles, La.
Ward, Thomas W.
South Gate, Calif.
Wardrop, William R. Buffalo, N. Y.
Waring, W. H. Houston, Tex.
Warner, Eugene C. Barberton, Ohio
Warren, Roy Steven
New Iberia, La.
Warren, Sam M. Wilmington, Calif.
Wasco, Joseph L. Midland, Mich.
Wasp, Edward J. Library, Pa.
Wasson, Robert R. Chicago, Ill.
Waterfield, Joseph H. Monroe, La.
Waterman, Howard E. Boise, Idaho
Waters, F. O. Los Angeles, Calif.
Waters, Robert G. Chicago, Ill.
Watkins, Donald C.
Bartlesville, Okla.
†Watkins, Franklin M. Harvey, Ill.
Watkins, Jesse L.
Colorado City, Tex.
Watson, A. D. Houston, Tex.
Watson, Amasa H., Jr.
Fort Smith, Ark.
Watson, John A., Jr.
Brooklyn, N. Y.
Watson, M. P. New Orleans, La.
Watson, Roger D. El Paso, Tex.
Watson, T. R. B.
Toronto, Ontario, Canada
Watson, W. E. Dallas, Tex.
*Watts, Admiral A. Columbus, Ohio
Watts, Bruce B. Lincoln, Neb.
Watts, John C., Jr. Houston, Tex.
Weart, James G. Springfield, Ill.
Weast, Robert C. Cleveland, Ohio
Weaver, James E. Houston, Tex.
Weber, Martin K. Emeryville, Calif.
Weber, Paul P. Marshall, Tex.
Weidler, W. E. Jr. Houston, Tex.
Weinland, B. W. Centralia, Ill.
Weir, C. J., Jr.
San Luis Obispo, Calif.
Weise, F. F. Wood River, Ill.
Weiser, Lemoine D. Topeka, Kan.
Weisert, Robert H. Chicago, Ill.
Welch, Pierre R. Hamilton, Ohio
†Welch, William, Jr. Mineola, N. Y.
Wells, C. Kenyon
Long Beach, Calif.
Welsh, Myron E. Houston, Tex.
Werckle, Joseph Houston, Tex.
Werner, Arthur Daniel
Houston, Tex.
Werner, Daniel R. Kansas City, Mo.
Werner, Sanford F.
Webster Groves, Mo.
Wertz, Cyril J. Cleveland, Ohio
†Wescott, Blaine B. Pittsburgh, Pa.
West, Charles Howard
Elizabeth, N. J.
West, John B. Atlanta, Ga.
West, Lewis H. Norwood, Pa.
Westcott, Ralph M.
La Canada, Calif.
Westerhof, Elmer E. Jackson, Mich.
Westermann, Donald H.
Cudahy, Wis.
Wey, George L.
South Boston, Mass.
Wheatlake, B. K. Denver, Colo.
Wheeler, A. W. Shreveport, La.
Wheeler, Lionel Harris
Houston, Tex.
Wheeler, Roger M. Tulsa, Okla.
†Whelan, J. T. Neenah, Wis.
Whelan, Thomas, Jr. Houston, Tex.
Whidden, Ira Miami, Fla.
†Whitaker, H. E. New York, N. Y.
White, Howard R.
Huntington, W. Va.
White, Robert L. Degolia, Pa.
White, Robert P. Bartlesville, Okla.
†White, W. C. Atlanta, Ga.
†White, W. J. Salina, Kan.
White, William K., Jr.
Providence, R. I.
Whitehead, Allen H.
New Orleans, La.
Whiteneck, L. L.
Long Beach, Calif.
Whiting, L. R. New York, N. Y.
Whitley, B. J., Jr. Hamburg, N. Y.
Whitman, John E.
Los Angeles, Calif.
Whitmore, Clifton W. Miami, Fla.
†Whitney, F. L., Jr. St. Louis, Mo.
†Whitney, George W.
Los Angeles, Calif.
Whitney, Roy P. Appleton, Wis.
Whittier, Frederick, Pittsburgh, Pa.
†Wicen, R. E. Milwaukee, Wis.
*Wickens, T. L. Houston, Tex.
Wickman, Emil E.
San Francisco, Calif.
Wiegers, Conrad L.
Charleston, W. Va.
Wilbanks, Hugh, Jr.
Corpus Christi, Tex.
Wilcock, Walter
Windsor, Ontario, Canada
†Wilde, H. D. Houston, Tex.
Wiles, Verland K. Cleveland, Ohio
Wiley, Lloyd R., Jr. Dallas, Tex.
†Wilgus, H. M. New York, N. Y.
†Wilkes, Frank M. Shreveport, La.
Wilkes, John F. Chicago, Ill.
Wilkins, Archie M. Kilgore, Tex.
†Wilkinson, A. C.
Ponca City, Okla.
Williams, Charles W.
Louisville, Ky.
Williams, Dale E.
Youngstown, Ohio
†Williams, David R., Jr.
Tulsa, Okla.
Williams, Frank L.
New York, N. Y.
Williams, Geo. T. Davenport, Iowa
†Williams, Guy F. Tulsa, Okla.
Williams, Josephine L.
Cincinnati, Ohio
Williams, Leonard W.
Coatesville, Pa.
Williams, Luther F.
San Francisco, Calif.
Williams, Robert D.
New Kensington, Pa.
Williams, Robert W.
Baton Rouge, La.
Williams, Sanders A.
Baltimore, Md.
Williams, Thomas P.
Philadelphia, Pa
†Williamson, Merritt A.
Hammond, Ind.
Williamson, P. Kent
Harrisburg, Pa.
†Williamson, T. D., Jr.
Tulsa, Okla.
Williamson, Theodore Dallas, Tex.
Willis, Stanley J.
Minneapolis, Minn.
Willson, B. F.
Edmonton, Alberta, Canada
Willson, Keith E. Tulsa, Okla.
†Wilmoth, E. G. Enid, Okla.
Wilson, Bert Irving, Tex.
Wilson, Charles H. Houston, Tex.
†Wilson, D. W. Cleveland, Ohio
Wilson, Edwin L. Chicago, Ill.
Wilson, Fred V. Port Arthur, Tex.
Wilson, J. B. St. Louis, Mo.
Wilson, John R. McKeesport, Pa.
Wilson, L. Alexander
Marcus Hook, Pa.
Wilson, Norman D. Ankeny, Iowa
Wilson, Robert C. Akron, Ohio
Wilson, Rushen A. Milwaukee, Wis.
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HACKENSACK

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EBERHARDT, T. J., Subox, Inc., Fairmount Plant.
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KRYSTOW, Paul, Colgate-Palmolive-Peet Co., 105 Hudson St.
SHIER, Mannith, National Molded Piping Distributors, 387 West Side Ave.
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SMITH, Walter R., Nukem Products Corp., 111 Colgate Ave.
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KROCKMALSKI, Edward, Corning Glass Works.
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DOBBS FERRY

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HAMBURG

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CLIFFORD, Hugh J., General Motors Corp., Harrison Radiator Div.
GODFREY, John W., General Motors Corp., Harrison Radiator Div.
LAWTON, Ledra M., General Motors Corp., Harrison Radiator Div., Washburn.
ROGERS, Philip S., General Motors Corp., Harrison Radiator Div.

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COLLINS, Harry S., Metallizing Engineering Co., Inc., 38-14 30th St.
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FRIEDMAN, Charles, Paragon Paint & Varnish Corp., 5-49 46th Ave.
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ALTENBURG, Charles J., Gibbs & Cox, Inc., 21 West St.
ANDERSON, Harry A., Hills McCanna Co., 30 Church St.
ANDREW, Harold O., Moore-Publishing Co., Inc., 48 West 38th St.
AYRES, Robert F., Oakite Products, Inc., 22 Thames St.
BAGNELL, William E., Ebasco Services, Inc., 2 Rector St.
BAILEY, Clark A., Johns-Manville Sales Corp., 22 E. 40th St.
BANKS, J. A. Davis, American Hard Rubber Co., 93 Worth St.
BALDWIN, L. A., Johns-Manville Sales Corp., 22 East 40th St.
BARRON, Donald W., Albert F. Ganz, Inc., 511 5th Ave.
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CARPENTER, Howard B., Esso Standard Oil Co., 15 West 51st St.
CLEMENT, Albert J., Ebasco Services, Inc., 2 Rector St.
COLE, Frank H., Walworth Co., 60 East 42nd St.
COLLINS, James H., Ebasco Services, Inc., 2 Rector St.
COLLINS, Walter F., New York Central System, 466 Lexington Ave.
COURT, W. F., Shell Oil Co., Inc., 50 West 50th St.
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COYLE, T. G., United Chromium, Inc., 100 East 42nd St.
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DAVIS, Russell L., California-Texas Oil Co., 551 5th Ave.
DAW, Ronald F., The Texas Co., 135 East 42nd St.
De LASKI, Robert D., W. A. Briggs Bitumen Co., 30 Church St.
De MEY, C. F., Columbia Engineering Corp., 120 East 41st St.
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FRIEND, W. Z., International Nickel Co., Inc., 67 Wall St.
FRIZ, Nelson, Esso Standard Oil Co., 15 West 51st St.
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HOOPER, Raymond R., Cities Service Oil Co., 70 Pine St.
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MAY, Thomas P., International Nickel Co., Inc., 67 Wall St.
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McCABE, Joseph C., "Power" Magazine, 330 West 42nd St.
McDERMOTT, Franklin, Lever Brothers Co., 390 Park Ave.
McKIRRYHER, Martin J., C. Raymond Ahrens, Inc., 30 Church St.
McNAMARA, Ambrose J., North & Judd Manufacturing Co., 71 West 23rd St.
MEIER, Alfred O., Shell Oil Co., 50 West 50th St.
MERRILL, Timothy W., Vanadium Corporation of America, 420 Lexington.
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SHOCK, D. A., Continental Oil Co., Drawer 1267.
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MINNICK, Arvel L., Oklahoma Natural Gas Co., 213 N. Broadway.

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BOSLEY, Samuel E., Owens-Corning Fiberglas Corp. For mail: 2949 East 22nd St.
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BRAND, John W., Midwestern Engine & Equipment Co., Inc., Box 1886.
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BRUNKOW, Ivan L., Tulsa Pipe Coating Co., Box 3085, Whittier Station.
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CARDWELL, Paul H., Dowell Inc., Box 536.
CARMICHAEL, Miles, Cathodic Servicing Co., 134 Heavy Trafficway.
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PORTER, Lew F., University of Wisconsin, College of Eng., Dept. of Mining & Metallurgy, 1509 University Ave.

MANITOWOC

RIHA, Robert, Heresite & Chemical Co., 822 S. 14th St.

MILWAUKEE

ANDRUS, Orrin E., A. O. Smith Corp., 3533 North 27th St.
BECKWITH, Laurence J., Wisconsin Electric Power Co., 3721 McKinley Ave.
CHARTER, Kenneth F., A. O. Smith Corp.
COTTON, William J., W. J. Cotton Laboratories, 3530 W. Fairmount Ave.
DERINGER, Wayne A., A. O. Smith Corp., 3533 North 27th St.
ELLIOTT, William E., Allis-Chalmers Mfg. Co., Box 512.
ERNST, Jacob W., Chain Belt Co., 1600 W. Bruce.
FRIEDEN, Alexander, Pabst Laboratories, 1037 W. McKinley Ave.
GEISSINGER, Richard M., Minert Pump & Engineering Co. For mail: 6140 W. Appleton Ave.
GIFFORD, Edmund W., Himelblau, Byfield & Co., 530 North Jackson St.
HAASE, Harold F., Eng. College, Marquette University. For mail: 2917 West Juneau Ave.
HANSEN, Arnold William, Bridgeport Brass Co., 312 E. Wisconsin Ave.
HAYNER, Donald L., Milwaukee Gas Light Co. For mail: 3301 North 89th St.
HERBST, Irene A., A. O. Smith Corp., 3533 North 27th St.
HUSEBY, Robert A., A. O. Smith Corp., 3533 North 27th St.
IMHOFF, Carroll E., Allis-Chalmers Mfg. Co., Box 512.
KEDZIE, Donald P., 3819 S. Hanson St.
KOEHLER, Donald N., Milwaukee Gas Light Co., 626 E. Wisconsin Ave.
LENDVED, John W., Chain Belt Co., 4500 W. Greenfield.
LEVINSON, Irving S., Ampco Metal, Inc., Process Industries, 1745 South 38th St.
MARTIN, Arthur R., Himelblau, Byfield & Co., 530 N. Jackson St.
MILLER, Charles E., Socony Vacuum Oil Co., Inc., 907 South 1st.
NELSON, Forrest W., A. O. Smith Corp., 3533 North 27th.
SCHEIL, Merrill A., A. O. Smith Corp., Box 584.
SCHROEDER, Clarence E., Mohns Bros. Co., 1751 North 3rd St.
SEIDENSTRICKER, R. A., Chain Belt Co., Process Equipment Div. For mail: 2151 North 56th St.
VAHLDIECK, Nathan P., Allis Chalmers Manufacturing Co., Box 512.
VOGEL, Henry A., Pittsburgh Plate Glass Co., 235 E. Pittsburgh Ave.
WICEN, R. E., Chain Belt Co. of Milwaukee, 1600 West Bruce St.
WILSON, Rushen A., 3233 South 21st St.
WOOLDRIDGE, Kent E., Aluminum Company of America, 735 N. Water.

NEENAH

BURNSIDE, Carl B., Kimberly-Clark Corp.
WHELAN, J. T., Kimberly-Clark Corp., Kimlark Plant.

RACINE

BRINEN, Howard F., Young Radiator Co. For mail: 2226 Kinzie Ave.
ORAVETZ, Julius A., Water Department Engineers, Fort Sheridan, Ill. For mail: 3406 Wright Ave.
PEIRCE, Walter A., Racine Water Department, City Hall.

SOUTH MILWAUKEE

AMUNDSON, Roald H., Line Material Co., 2201 12th Ave.
MOMOI, James, Kyle Products Plant, 9th & Marion Aves.

WAUKESHA

McCLINTOCK, Robert D., Michigan-Wisconsin Pipe Line Co., Detroit, Mich. For mail: 232 W. Main.
THOMAS, Ralph W., Waukesha Foundry Co., Lincoln Ave.

WEST ALLIS

SPANGENBERG, Robert F., Pressed Steel Tank Co., 1445 South 66th St.

WHITEFISH BAY

SCHNEIDER, John H., Pennsylvania Salt Manufacturing Co., Philadelphia, Pa. For mail: 4858 N. Berkeley Blvd.

WISCONSIN RAPIDS

KLINGER, Lloyd L., Consolidated Water Power & Paper Co.

WYOMING

CASPER

KRUEGER, Louis T., Northern Utilities Co., Box 1091.

CODY

COLLOPY, Joseph P., U. S. Bureau of Reclamation. For mail: 1719 Salsbury Ave.

ROCK SPRINGS

BASSANI, Fiorentino F., Mountain Fuel Supply Co. For mail: Box 326.

FOREIGN

ARGENTINA

BUENOS AIRES

BLANCO, Felix F., Chiclana 324, Bernal.
HICKETHIER, Carlos F., Azcuenaga 1183-93

AUSTRALIA

MELBOURNE

DAVIES, Alan T., The Phosphate Co-Operative Co. of Australia, Ltd., 447 Little Collins St.
HOPKINS, Arthur James, Hume Steel Ltd., P. O. Box 4534.
JOHNSON, W. A., Melbourne & Metropolitan Board of Works, 110 Spencer St.

BELGIUM

BRUSSELS

POURBAIX, M. J., Centre Belge D'Etende de la Corrosion.
VAN RYSSELBERGE, Maurice, care A. B. E. M. IV, 25 Rue Du Champ de Mars.

BRITISH WEST INDIES

TRINIDAD

RITCHIE, Robert, Trinidad Leaseholds, Ltd., Pointe-A-Pierre.

CANADA

CALGARY, ALBERTA

BROWNIE, F. A., The Canadian Western Nat. Gas Co., Ltd., 215 6th Avenue West.
GATTENMEYER, John L., Shell Oil Co., Box 100.
KELLAM, G. D., Canadian West Natural Gas, 215 6th Avenue West.
PYOTT, William T., Mannix, Ltd.
SNYDER, B. W., Canadian Western Natural Gas Co., Ltd., 215 Sixth Avenue West.
YOUNG, James W., 1409 Premier Way.

EDMONTON, ALBERTA

ALLISON, Norman J., Interprovincial Pipe Line Co., 8221 109th St.
CRUMBACK, A. Lloyd, Canadian Equip. Sales & Service Co., Ltd., 7310 99th.
MOUNT, W. R., Waterworks Distribution System, City of Edmonton.
STUBBS, F. J., Interprovencial Pipe Line Co., 8221 109th St.
WILLSON, B. F., Northwestern Utilities, Ltd., 10124 104th St.
YORATH, D. K., Northwestern Utilities, Ltd., 10124 104th St.

TURNER VALLEY, ALBERTA

PIERCEY, Alexander George Arthur, Madison Natural Gas Co., Ltd.

TRAIL, BRITISH COLUMBIA

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CHATHAM, ONTARIO

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TORONTO, ONTARIO

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JOPP, J. M., Brown Corp.

LENNOXVILLE, QUEBEC

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CARTAGENA

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PADRON, Felix G. Martinez, Cuban Telephone Co., Aguila y Dragones.

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HURST, S., Tretol Limited, 12-14 North End Road, Golders Green.
MOHR, Bernard, H. Windsor & Co., Ltd., 230 232 Acton Lane, Chiswick.
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STRACHAN, John F., Anglo-Iranian Oil Co., Ltd., Britannic House, Finsbury Circus.

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TUPHOLME, Charles B., Samuel Fox & Company, Ltd., Stocksbridge Works.

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JAPAN

TOKYO

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SHIGENO, Hayata, 105 Fusuma-Cho, Meguro-Ku.

OSAKA

TANAKA, Michio, Kansai Denryoku K.K., Tech. Lab., 1-Chome, Kujo-Minami-Dori, Nishi-Ku.

LEBANON

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MEXICO, D. F.

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ROSITA, COAHUILA

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TAMPICO, TAMPS.

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DELFT

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EINDHOVEN

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GELEEN

ZELDERS, Herman G., Bibliotheek Staatsmijnen, Centraal Laboratorium.

THE HAGUE

POST, J. H. G., N. V. De Bataafsche Petroleum Mij., Carel Van Bylandtlaan 30.
VAN DER HOEVEN, H., N. V. De Bataafsche Petroleum Mij., Carel Van Bylandtlaan 30.
VAN DER VELDE, Fa. J. C., Van Der Velde-Henning, Franzen, Hofwijckplein 32.

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ARUBA

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SEGEL, Kalman, Esso, Box 667.

CURACAO

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PAKISTAN

WEST PUNJAB

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PERSIAN GULF PORTS

AHMADI, KUWAIT

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PUERTO RICO

SANTURCE

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SAUDI ARABIA

DHAHRAN

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RAS EL MISHAAB

SHULTZ, S. T., Arabian-American Oil Co.

SPAIN

BARCELONA

GRAU, Vicente Massuet, Instituto Electroquimico, Sanz y Massuet, S. A.

SWEDEN

STOCKHOLM

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SYRIA

HOMS

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TERRITORY OF HAWAII

HILO

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HONOLULU

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VENEZUELA

CABINAS, ESTADO ZULIA

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SEARCY, John E., Jr., Creole Petroleum Corp.

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JONES, R. M., Liquid Carbonic Venezolana, S. A., Parate Bueno-Antimano.
MACHADO, Oscar, La Electricidad De Caracas, Marron A Pelota No. 8.
McCAMMON, G. A., Creole Petroleum Corp., Apartado 889.
MOLNAR, Eric G., Texas Petroleum Co., Apdo. 267.
TOWNE, Robert L., Creole Petroleum Corp., Pipe Line Sec., Apartado 889.

CARIPITO, MONAGAS

STOBAUGH, Robert B., Jr., care Creole Petroleum Corp.

LAS PIEDRAS FALCON

THATCHER, Fred G., care Creole Petroleum Corp.
VAN DER BAAN, Sj., care Shell V.O.C., Refineria Cardon.

MARACAIBO

LOWE, Richard A., Shell Caribbean Petroleum Co., Apartado 19.

TECHNICAL PRACTICES COMMITTEES

TP-1 Corrosion of Oil and Gas Well Equipment (Formerly Condensate Well Corrosion)

TP-2 Galvanic Anodes for Cathodic Protection

TP-3 Anodes for Use With Impressed Currents

TP-4 Minimum Current Requirements for Cathodic Protection.

TP-5 Corrosion Problems Involved in Processing and Handling Chemicals

TP-6 Protective Coatings

TP-7 Materials for Use At High Temperatures

TP-8 Corrosion By Waters

TP-9 Corrosion Inhibitors

TP-10 Corrosion Fatigue

TP-11 Identification of Corrosion Products

TP-12 Effect of Electrical Grounding on Corrosion

TP-13 Annual Losses Due to Corrosion

TP-14 Instruments for Corrosion Measurements

TP-15 Corrosion Control In the Transportation Industries

TP-16 Electrolysis and Corrosion of Cable Sheaths

TP-17 Standardization of Procedure for Measuring Pipe Coating Conductance

TP-18 Internal Corrosion of Facilities for Storage and Transportation of Petroleum

TP-19 Corrosion By De-Icing Salts

Corporate‡ Members

(With Representatives)

Addresses in the following list are not necessarily those of the corporate member representatives named. For mailing addresses of corporate member representatives refer to the alphabetical and geographical lists herein.

ALABAMA GAS CORP.
Birmingham, Ala., Charles B. Gamble, Jr.

ALLEGHENY LUDLUM STEEL CORP.
Brackenridge, Pa., William G. Renshaw

ALLIED CHEMICAL & DYE CORP., BARRETT DIV.
New York, N. Y., B. C. Cowart

ALLOY STEEL PRODUCTS CO.
Linden, N. J., Emil G. Holmberg

ALUMINUM COMPANY OF AMERICA
New Kensington, Pa., Ellis D. Verink, Jr.

ALUMINIUM LABORATORIES, LTD.
Kingston, Ontario, Canada, H. P. Godard

AMERCOAT CORP.
South Gate, Calif., C. G. Munger

AMERICAN BRAKE SHOE CO.
New York, N. Y., Robert B. Parker

AMERICAN BRASS CO., THE
Waterbury, Conn., John R. Freeman, Jr.

AMERICAN CAN COMPANY
Maywood, Ill., L. P. Gotsch

AMERICAN GAS & ELECTRIC SERVICE CORP.
New York, N. Y., Robert E. Morse

AMERICAN PETROLEUM CO.
Houston, Tex., John B. Jared, Jr.

AMERICAN SMELTING AND REFINING CO., FEDERATED METALS, DIV.
New York, N. Y., R. D. Taylor

AMERICAN STEEL & WIRE CO., DIV. U. S. STEEL CO.
Cleveland, Ohio, R. T. Lowerre

AMERICAN TELEPHONE & TELEGRAPH CO.
New York, N. Y., John W. Danser

AMERICAN TOBACCO CO., THE
Richmond, Va., R. Peele Hackney

AMERICAN ZINC, LEAD AND SMELTING CO.
St. Louis, Mo., Robert Ammon

ANDERSON BROS. CORP.
Houston, Tex., W. A. Rose

ANGLO-IRANIAN OIL CO., LTD.
New York, N. Y., W. D. Heath Eves

APEX SMELTING CO.
Chicago, Ill., A. J. Peterson

ARKANSAS FUEL OIL CO.
Shreveport, La., L. F. Babcock

ARKANSAS LOUISIANA GAS CO.
Shreveport, La., W. A. Broome

ARMCO STEEL CORP.
Middletown, Ohio, Arba Thomas

ASHLAND OIL & REFINING CO.
Ashland, Ky., James F. Thistle

ASSOCIATED PIPE LINE CONTRACTORS
Houston, Tex., A. L. Forbes, Jr.

ATCHISON, TOPEKA & SANTA FE RY. CO., THE
Chicago, Ill., E. E. Chapman

ATLANTIC REFINING CO., PROD. DIV., THE
Dallas, Tex., V. E. Stepp

ATLANTIC REFINING CO., REFINING DIV., THE
Philadelphia, Pa., J. K. Deichler

ATLAS MINERAL PRODUCTS CO., THE
Mertztown, Pa., Raymond B. Seymour

ATLAS POWDER CO.
Wilmington, Del., Marion D. Caldwell

AXELSON MANUFACTURING CO.
Los Angeles, Calif., E. F. Green

BABCOCK AND WILCOX CO., THE
Alliance, Ohio, F. Eberle

BART MANUFACTURING CO.
Belleville, N. J., S. G. Bart

BATAAFSCHE PETROLEUM MAATSCHAPPIJ, N. V. DE
The Hague, Netherlands, H. Van der Hoeven

BECHTEL CORP.
Wilmington, Calif., Jasper S. Connell

BELL TELEPHONE LABORATORIES
Murray Hill, N. J., Vernon B. Pike

BETHLEHEM STEEL CO.
Bethlehem, Pa., Seymour Charles Frye

BOWSER, INC.
Fort Wayne, Ind., Paul A. Mankin

BRANCE-KRACHY CO., INC.
Houston, Tex., Wayne E. Broyles

BRIDGEPORT BRASS CO.
Bridgeport, Conn., C. L. Bulow

BRIGGS BITUMINOUS COMPOSITION CO.
Philadelphia, Pa., J. D. Farber

BUCKEYE PIPE LINE CO., THE
New York, N. Y., A. J. Helmbrecht

BYERS, A. M., CO.
Pittsburgh, Pa., J. W. Marrinan

BYRON JACKSON COMPANY
Los Angeles, Calif., M. B. Riordan

CALIFORNIA CO., THE
New Orleans, La., E. M. Kipp

CALUMET AND HECLA CONSOLIDATED COPPER CO.
Decatur, Ala., H. E. Honkala

CAMERON IRON WORKS, INC.
Houston, Texas, Jack W. Harris

CANADIAN WESTERN NATURAL GAS CO., LTD.
Calgary, Alberta, Canada, B. W. Snyder

CARTER OIL CO., THE
Tulsa, Okla., A. T. Clothier

CASEY AND CASE COATING CO.
Los Angeles, Calif., Robert A. Glasgow

CATERPILLAR TRACTOR CO.
Peoria, Ill., George P. Fenn

CATHODIC SERVICING CO.
Tulsa, Okla., Miles Carmichael

CELANESE CORPORATION OF AMERICA
New York, N. Y., H. M. Wilgus

CENTRAL POWER & LIGHT CO.
Corpus Christi, Tex., William M. Mayer

CENTRE BELGE D'ETUDE DE LA CORROSION
"CEBELCOR" Brussels, Belgium. Marcel Pourbaix

CHAIN BELT COMPANY OF MILWAUKEE
Milwaukee, Wis., R. E. Wicen

CHAMPLIN REFINING CO.
Enid, Okla., E. G. Wilmoth

CHANSLOR CANFIELD MIDWAY OIL CO.
Los Angeles, Calif., H. L. Briggs

CHASE BRASS & COPPER CO.
Waterbury, Conn., N. W. Mitchell

CHICAGO BRIDGE & IRON CO.
New York, N. Y., Fred L. Goldsby

CINCINNATI GAS & ELECTRIC CO., THE
Cincinnati, Ohio, Milton J. Pfeiffer

CIT-CON OIL CORP.
Lake Charles, La., Robert L. Hale, Jr.

CITIES SERVICE GAS CO.
Oklahoma City, Okla., George H. Baird

CITIES SERVICE PIPE LINE CO.
Bartlesville, Okla., Harry Nelson

CITIES SERVICE REFINING CORP.
Lake Charles, La., L. D. Mann

‡The revised Articles of Organization which became effective January 1, 1950, incorporates the grades of membership formerly designated as "Associate" and "Corporate," into one grade of membership designated as "Corporate".

CLARK BROTHERS, CO., INC.
Olean, N. Y., D. K. Hutchcraft

CLEVELAND ELECTRIC ILLUMINATING CO., THE
Cleveland, Ohio, Clarence J. Beller

COLORADO INTERSTATE GAS CO.
Colorado Springs, Colo., Charles B. Abbot

COLUMBIA ENGINEERING CORP.
New York, N. Y., C. F. De Mey

COLUMBIA-SOUTHERN CHEMICAL CORP.
Barberton, Ohio, Paul J. Gegner

COLUMBIA-SOUTHERN CHEMICAL CORP.
Corpus Christi, Tex., John R. Polhamus

COLUMBUS AND SOUTHERN OHIO ELECTRIC CO.
Columbus, Ohio, Frank H. Streit

COMMERCIAL SOLVENTS CORP.
Terre Haute, Ind., Richard S. Egly

COMMONWEALTH EDISON CO.
Chicago, Ill., Alex D. Bailey

CONSOLIDATED CHEMICAL INDUSTRIES, INC.
Houston, Tex., E. S. Rothrock

CONSOLIDATED EDISON CO. OF NEW YORK, INC.
New York, N. Y., L. B. Donovan

CONSOLIDATED GAS ELECTRIC LIGHT & POWER CO. OF BALTIMORE
Baltimore, Md., T. J. Dwyer

CONSOLIDATED MINING & SMELTING CO. OF CANADA, LTD., THE
Division Trail, B. C., Canada, A. H. W. Busby

CONSUMERS POWER CO.
Jackson, Mich., D. E. Herringshaw

CONTINENTAL PIPE LINE CO.
Ponca City, Okla., A. C. Wilkinson

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Mount Vernon, Ohio, H. A. Gehres

CORN PRODUCTS REFINING CO., CHEMICAL DIV.
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COSDEN PETROLEUM CORP.
Big Spring, Tex., R. W. Thompson

CRANE CO.
Chicago, Ill., J. Pat Casey, Jr.

CREOLE PETROLEUM CORP.
Caracas, Venezuela, S. A., G. A. McCammon

CROWN CENTRAL PETROLEUM CORP.
Houston, Tex., H. S. Lane

CRUCIBLE STEEL COMPANY OF AMERICA
Pittsburgh, Pa., E. W. Hopper

CRUTCHER-ROLFS-CUMMINGS
Houston, Tex., G. H. Osborn

DALLAS POWER & LIGHT CO.
Dallas, Tex., Robert D. Elliott

DAY, S. D., CO.
Houston, Tex., David W. Peake

DEARBORN CHEMICAL CO.
Chicago, Ill., E. M. Converse

DEEP ROCK OIL CORP.
Tulsa, Okla., J. G. Campbell

DENVER COMMITTEE ON ELECTROLYSIS, THE
Denver, Colo., Kenneth A. Day

DIAMOND ALKALI COMPANY
Painesville, Ohio, C. A. Butler, Jr.

DOUGLAS AIRCRAFT CO., INC.
Santa Monica, Calif., F. T. Wood, Jr.

DOW CHEMICAL CO., THE
Midland, Mich., H. A. Humble

DOWELL INCORPORATED
Tulsa, Okla., Guy F. Williams

DU PONT, E. I., DE NEMOURS & CO., INC.
Wilmington, Del., W. R. Myers

DURIRON CO., THE
Dayton, Ohio, G. A. Baker

DUVAL SULPHUR AND POTASH CO.
Carlsbad, N. M., J. W. Borskey, Jr.

EAST BAY MUNICIPAL UTILITY DISTRICT
Oakland, Calif., David Hendrickson

EAST OHIO GAS CO., THE
Cleveland, Ohio, F. E. Vandaveer

EASTERN STATES PETROLEUM CO., INC.
Houston, Tex., Ewald A. Roesler

EBASCO SERVICES INC.
New York, N. Y., M. C. Miller

ELECTRO RUST-PROOFING CORP.
Belleville, N. J., R. T. Browning

EL PASO NATURAL GAS CO.
El Paso, Tex., C. L. Perkins

EMPIRE DISTRICT ELECTRIC CO., THE
Joplin, Mo., Earl Drewelow

EMSCO DERRICK & EQUIPMENT CO.
Los Angeles, Calif., George W. Whitney

ETHYL CORP.
Baton Rouge, La., C. C. Harvey

FERRO ENAMEL CORP.
Cleveland, Ohio, G. H. McIntyre

FLINTKOTE CO., THE
New York, N. Y., Frank H. Neher

FOOD MACHINERY & CHEMICAL CORP., WESTVACO CHEMICAL DIVISION
New York, N. Y., Sydney Lawless

FORD, BACON & DAVIS, INC.
New York, N. Y., H. E. Whitaker

FREEPORT SULPHUR CO
Freeport, Tex., L. A. Nelson, Jr.

GENERAL AMERICAN TRANSPORTATION CORP.
Chicago, Ill., Paul Talmey

GENERAL ELECTRIC CO., INDUSTRIAL MATERIALS DIV.
Schenectady, N. Y., W. A. Wirene

GENERAL PAINT CORP., HILL-HUBBELL DIV.
Cleveland, Ohio, Milton W. Bowen

GENERAL PETROLEUM CORP.
Los Angeles, Calif., Turner C. Smith

GLASFLOSS CORP., THE
Hicksville, N. Y., W. F. Yahnker

GLASS FIBERS, INC.
Toledo, Ohio, R. W. Capaul

GLOBE OIL & REFINING CO., THE
Lemont, Ill., J. M. Lawson

GOODALL ELECTRIC MANUFACTURING CO.
Ogallala, Neb., R. A. Goodall

GOODYEAR TIRE & RUBBER CO., INC., THE, CHEMICAL DIV.
Akron, Ohio, H. R. Thies

GRANITE CITY STEEL CO.
Granite City, Ill., George A. Holtzscher, Jr.

GRAVER TANK & MANUFACTURING CO., INC.
East Chicago, Ind., H. L. O'Brien

GREAT LAKES PIPE LINE CO.
Kansas City, Mo., C. C. Keane

GULF OIL CORP.
Houston, Tex., Walter F. Rogers

GULF OIL CORP., MANUFACTURING DIV.
Port Arthur, Tex., D. L. Burns

GULF RESEARCH & DEVELOPMENT CO.
Pittsburgh, Pa., Blaine B. Wescott

GULF STATES UTILITIES CO.
Beaumont, Tex., W. W. Eckles

HACKENSACK WATER CO.
Weehawken, N. J., C. J. Alfke

HALLIBURTON OIL WELL CEMENTING CO.
Duncan, Okla., Francis M. Anderson

HARPER, H. M., CO., THE
Morton Grove, Ill., Tom Stott

HERCULES POWDER CO.
Wilmington, Del., R. F. Schultz

HOOKER ELECTROCHEMICAL CO.
Niagara Falls, N. Y., Joseph E. Thornberg

HOUSTON CONTRACTING CO.
Houston, Tex., R. P. Gregory

HOUSTON NATURAL GAS CORP.
Houston, Tex., C. A. Blanchard

HOUSTON PIPE LINE CO.
Houston, Tex., C. Lee Wood

HUMBLE OIL & REFINING CO.
Houston, Tex., H. D. Wilde

HUMBLE PIPE LINE CO.
Houston, Tex., O. Q. Lomax

INLAND STEEL CO.
East Chicago, Ind., R. L. Harbaugh

INTERNATIONAL HARVESTER CO.
Chicago, Ill., Earl F. Moorman

INTERNATIONAL MINERALS & CHEMICAL CORP.
Chicago, Ill., Paul D. V. Manning

INTERNATIONAL NICKEL CO., INC.
New York, N. Y., W. Z. Friend

INTERPROVENTIAL PIPE LINE CO.
Edmonton, Alberta, Canada, F. J. Stubbs

INTERSTATE NATURAL GAS CO.
Monroe, La., O. C. Roddey

INTERSTATE OIL PIPE LINE CO.
Shreveport, La., Robert L. Bullock

IOWA PUBLIC SERVICE CO.
Sioux City, Iowa, Wm. J. Dougherty

JOHNS-MANVILLE SALES CORP.
New York, N. Y., L. A. Baldwin

JONES & LAUGHLIN STEEL CORP.
Pittsburgh, Pa., H. W. Graham

KAISER STEEL CORPORATION
Fontana, Calif., Richard Aubrey

KANSAS-NEBRASKA NATURAL GAS CO., INC.
Hastings, Neb., Leonard C. Hill

KANSAS POWER & LIGHT CO., THE
Salina, Kan., W. J. White

M. W. KELLOGG CO., THE
New York, N. Y., W. B. Hoyt

KENDALL CO., THE, BAUER AND BLACK DIV., POLYKEN INDUSTRIAL TAPE DEPT.
Chicago, Ill., William J. Miller

KEYSTONE PIPE LINE CO.
Philadelphia, Pa., Robert H. Lynch

KEYSTONE SHIPPING CO.
Philadelphia, Pa., S. F. Spencer

KIMBERLY-CLARK CORP.
Neenah, Wis., J. T. Whelan

KNAPP MILLS, INCORPORATED
Long Island City, N. Y., Alfred P. Knapp

KOPPERS CO., INC., TAR PROD. DIV.
Westfield, N. J., W. F. Fair, Jr.

LACLEDE GAS CO.
St. Louis, Mo., Delmar Hasenritter

LEBANON STEEL FOUNDRY
Lebanon, Pa., E. H. Platz, Jr.

LEVER BROTHERS CO.
New York, N. Y., Franklin McDermott

LION OIL COMPANY
El Dorado, Ark., J. B. Rogerson

LONE STAR GAS CO.
Dallas, Tex., J. L. Foster

LONG ISLAND LIGHTING CO.
Mineola, N. Y., William Welch, Jr.

LOUISIANA POWER & LIGHT CO.
New Orleans, La., W. T. Hess

MAGNOLIA PETROLEUM CO.
Beaumont, Tex., C. A. Knight

MAGNOLIA PIPE LINE CO.
Dallas, Tex., David Henry Levy

MAHONEY CONTRACTING CO.
Lansing, Mich., E. J. Mahoney, Jr.

MALLINCKRODT CHEMICAL WORKS
St. Louis, Mo., C. W. Swartout

MALONEY-CRAWFORD TANK AND MFG. CO.
Tulsa, Okla., Sam Wilson

MATHIESON CHEMICAL CORP.
Baltimore, Md., C. F. Prutton

MAVOR, JAMES E., CO.
Houston, Tex., Thos. F. P. Kelly

McKEE, ARTHUR G., & COMPANY
Cleveland, Ohio, D. W. Wilson

METALLIZING ENGINEERING CO.
Long Island City, N. Y., R. J. McWaters

METROPOLITAN WATER DISTRICT OF SO. CALIF.
Los Angeles, Calif., R. B. Diemer

MICHIGAN CONSOLIDATED GAS CO.
Detroit, Mich., Roland R. Paulin

MICHIGAN-WISCONSIN PIPE LINE CO.
Detroit, Mich., Anthony H. Cramer

MID-CONTINENT PIPE LINE CO.
Tulsa, Okla., F. E. Pyeatt, Jr.

MIDDLE WEST COATING & SUPPLY
Tulsa, Okla., Maynard H. Jackson

MIDSOUTH GAS CO.
Little Rock, Ark., W. A. Green

MIDWESTERN ENGINE AND EQUIPMENT CO., INC.
Tulsa, Okla., John W. Brand

MIDWEST PIPELINE SERVICE CO.
Houston, Tex., S. U. McGary

MIDWESTERN CONSTRUCTORS, INC.
Tulsa, Okla., C. C. Bledsoe

MINNESOTA MINING & MANUFACTURING CO.
Detroit, Mich., D. W. Maher

MISSOURI PACIFIC RAILROAD CO.
St. Louis, Mo., W. H. Hobbs

MISSISSIPPI GAS CO.
Meridian, Miss., H. K. Griffin

MISSISSIPPI POWER & LIGHT CO.
Jackson, Miss., G. C. Jones

MISSISSIPPI RIVER FUEL CORP.
St. Louis, Mo., G. B. Lowther

MOBILE GAS SERVICE CORP.
Mobile, Ala., Harold T. Strange

MONSANTO CHEMICAL CO.
St. Louis, Mo., F. L. Whitney, Jr.

MONTANA POWER CO.
Butte, Mont., Carl R. Davis

MOTOROLA, INC., COMMUNICATIONS & ELECTRONICS DIV.
Chicago, Ill., Eugene S. Goebel

MOUNTAIN FUEL SUPPLY CO.
Salt Lake City, Utah, Harry R. Brough

MUTUAL CHEMICAL CO. OF AMERICA
Baltimore, Md., George E. Best

MYERS, L. E., CO., THE
Chicago, Ill., Newton D. Rich

NATASCO CO.
Tulsa, Okla., J. C. Nicholson

NATIONAL ALUMINATE CORP.
Chicago, Ill., J. W. Ryznar

NATIONAL DISTILLERS PRODUCTS CORP.
Cincinnati, Ohio, L. A. Petrov

NATIONAL LEAD CO., RESEARCH LABORATORIES
New York, N. Y., Alex Stewart

NATIONAL SUPPLY CO., THE, SPANG-CHALFANT DIV.
Ambridge, Pa., Lawrence E. Trishman

NATIONAL TANK CO.
Tulsa, Okla., Clarence O. Glasgow

NATIONAL TUBE CO.
Pittsburgh, Pa., V. V. Kendall

NATURAL GAS PIPE LINE CO. OF AMERICA
Beatrice, Neb., A. F. Schmierer

NEW ORLEANS PUBLIC SERVICE, INC.
New Orleans, La., Lionel J. Cucullu

NEW YORK CENTRAL RAILROAD CO.
New York, N. Y., Harry W. Walsh

NEW YORK AND RICHMOND GAS CO.
Staten Island, New York, N. Y., R. Van Vliet

NICOLET INDUSTRIES, INC.
New York, N. Y., Philip A. Meyer

NOOTER CORP.
St. Louis, Mo., Walter Meyer

NORFOLK AND WESTERN RAILWAY CO.
Roanoke, Va., C. L. Crockett

NORTH PENN GAS CO.
Port Allegany, Pa., J. H. Isherwood

NORTHERN NATURAL GAS CO.
Omaha, Neb., W. B. Haas

NORTHWESTERN UTILITIES, LTD.
Edmonton, Alberta, Canada, D. K. Yorath

NUKEM PRODUCTS CORP.
Buffalo, N. Y., John W. Chandler

OAKITE PRODUCTS, INC.
New York, N. Y., Robert F. Ayres

OHIO-MICHIGAN PIPELINE DIV.
Wayne, Mich., Luis Garcia

OHIO OIL CO., THE
Findlay, Ohio, Ralph M. Slough

OIL WELL SUPPLY CO.
Oil City, Pa., F. L. Current

OKLAHOMA NATURAL GAS CO.
Tulsa, Okla., C. E. Cloud

OLIVER UNITED FILTERS, INC.
Oakland, Calif., E. D. Flynn

OMAHA AND COUNCIL BLUFFS ELECTROLYSIS COMMITTEE
Omaha, Neb., H. W. Bruhn

OTIS ELEVATOR CO.
New York, N. Y., Arthur E. Prince

OWENS-CORNING FIBERGLAS CORP.
Toledo, Ohio, W. H. Sedgeman

PABCO PRODUCTS, INC.
San Francisco, Calif., Maury Millar

PACIFIC GAS & ELECTRIC CO.
Emeryville, Calif., William R. Schneider

PAN AMERICAN PIPE LINE CO.
Houston, Tex., W. H. Bruyere

PANHANDLE-EASTERN PIPE LINE CO.
Kansas City, Mo., E. Buddrus

PARKHILL TRUCK CO.
Tulsa, Okla., Roy F. Parkhill

PENNSYLVANIA SALT MANUFACTURING CO.
Philadelphia, Pa., A. S. Woodard

PEOPLES GAS LIGHT AND COKE CO., THE
Chicago, Ill., Leo G. Ranta

PEOPLES NATURAL GAS CO., THE
Pittsburgh, Pa., C. A. Erickson, Jr.

PERRAULT BROTHERS
Tulsa, Okla., Lewis Perrault

PETROLEUM ENGINEERING, INC.
Dallas, Tex., Paul M. Raigorodsky

PHILADELPHIA ELECTRIC CO.
Philadelphia, Pa., Frank Kahn

PHILIP CAREY MANUFACTURING CO., THE
Lockland (Cincinnati), Ohio, V. V. Malcom

PHILLIPS PETROLEUM CO.
Bartlesville, Okla., Frederick A. Prange

PIPE LINE SERVICE CORP.
Franklin Park, Ill., F. C. Yeazel

PITTSBURGH COKE AND CHEMICAL CO.
Pittsburgh, Pa., Edward C. Vierling, Jr.

PLANTATION PIPE LINE CO.
Atlanta, Ga., W. G. Horstman

PORTLAND PIPE LINE CORP.
Portland, Maine, Carlton L. Goodwin

POTASH COMPANY OF AMERICA
Carlsbad, N. M., E. W. Douglass

POTASHNICK, R. B.
Cape Girardeau, Mo., R. B. Potashnick

PREMIER OIL REFINING COMPANY OF TEXAS
Ranger, Tex., David D. Pickrell

PRICE, H. C., CO.
Bartlesville, Okla., J. S. Dewar

PROCTER AND GAMBLE CO., THE
Cincinnati, Ohio, George F. Lockeman

PUBLIC SERVICE COMPANY OF NORTHERN ILLINOIS
Chicago, Ill., E. E. Lungren

PUBLIC SERVICE ELECTRIC AND GAS CO.
Newark, N. J., George H. Blake

PULLMAN-STANDARD CAR MANUFACTURING CO.
Hammond, Ind., Merritt A. Williamson

PURE TRANSPORTATION CO.
Chicago, Ill., D. C. Glass

REILLY TAR & CHEMICAL CORP.
Indianapolis, Ind., J. H. Barnett, Jr.

REPUBLIC STEEL CORP.
Youngstown, Ohio, Giles Locke

REYNOLDS METALS CO.
Louisville, Ky., J. R. Akers

RHEEM MANUFACTURING CO.
South Gate, Calif., Ralph Gieser

RICHFIELD OIL CORP.
Los Angeles, Calif., D. F. Purdy

ROCHESTER GAS AND ELECTRIC CORP.
Rochester, N. Y., R. E. Kruger

ROCKWELL MANUFACTURING CO., NORDSTROM VALVE DIV.
Pittsburgh, Pa., E. E. Matheson

ROSSON-RICHARDS CO.
Houston, Tex., S. L. Richards, Jr.

SAIGH, N. A., CO.
San Antonio, Tex., N. A. Saigh

SALT LAKE PIPE LINE CO.
Salt Lake City, Utah, Charles V. Baxter

SAN DIEGO GAS AND ELECTRIC CO.
San Diego, Calif., L. M. Klauber

SAN FRANCISCO WATER DEPT.
San Francisco, Calif., George W. Pracy

SARGENT & LUNDY
Chicago, Ill., Ludwig Skog, Jr.

SCHENLEY DISTILLERS, INC.
Cincinnati, Ohio, A. C. Greber

SCRANTON-SPRING BROOK WATER SERVICE CO.
Wilkes-Barre, Pa., Rulison Evans

SERVICE ENGINEERS, INC.
Fort Worth, Tex., James A. Clay, Jr.

SERVICE PIPE LINE CO.
Tulsa, Okla., J. R. Polston

SHAMROCK OIL AND GAS CORP., THE
Amarillo, Tex., Dan P. Long

SHANANHAN CONSTRUCTION CO. AND ASSOCIATES
St. Louis, Mo., J. P. Shanahan

SHELL CHEMICAL CORP.
New York, N. Y., C. I. Wright

SHELL DEVELOPMENT CO.
Emeryville, Calif., Aaron Wachter

SHELL OIL CO., INC.
New York, N. Y., W. F. Court

SHELL PIPE LINE CORP.
Houston, Tex., H. H. Anderson

SIGNAL OIL & GAS CO.
Los Angeles, Calif., E. O. Kartinen

SINCLAIR OIL AND GAS CO.
Tulsa, Okla., H. M. Coulson

SINCLAIR RESEARCH LABORATORIES, INC.
New York, N. Y., F. M. Watkins

SINCLAIR PIPE LINE CO.
Independence, Kan., Earl W. Unruh

SKELLY OIL CO.
Tulsa, Okla., Rex L. Smith

SLINE INDUSTRIAL PAINTERS
Houston, Tex., Louis L. Sline

SMITH, A. O., CORP.
Milwaukee, Wis., Orrin E. Andrus

SMITH CONTRACTING CORP.
Fort Worth, Tex., O. R. Smith

SOCONY-VACUUM OIL CO., INC., EASTERN PIPE LINE DIV.
Plainfield, N. J., S. Kleinheksel

SOHIO PIPE LINE CO.
Cleveland, Ohio, Earl G. Ellerbrake

SOLVENTS AND PLASTICS CO.
St. Louis, Mo., William T. Deacon

SOUTHEASTERN PIPE LINE CO.
Atlanta, Ga., B. W. Winters

SOUTHERN BELL TELEPHONE AND TELEGRAPH CO.
Atlanta, Ga., W. C. White

SOUTHERN COUNTIES GAS COMPANY OF CALIF.
Los Angeles, Calif., N. K. Senatoroff

SOUTHERN MINERALS CORP.
Corpus Christi, Tex., F. P. Peterson, Jr.

SOUTHERN NATURAL GAS CO.
Birmingham, Ala., O. W. Clark

SOUTHERN PACIFIC CO.
San Francisco, Calif., E. E. Mayo

SOUTHERN UNION GAS CO.
Dallas, Tex., J. C. Reid

SOUTHWESTERN GAS AND ELECTRIC CO.
Shreveport, La., Frank M. Wilkes

SPENCER CHEMICAL CO.
Pittsburg, Kan., Ralph D. Miller

STANDARD OIL COMPANY OF CALIFORNIA
San Francisco, Calif., J. M. Evans

STANDARD OIL COMPANY OF INDIANA
Chicago, Ill., L. W. Ewing

STANDARD OIL DEVELOPMENT CO.
Linden, N. J., M. S. Northup

STANDARD PIPE PROTECTION, INC.
St. Louis, Mo., Hugh W. Baird

STANDARD RAILWAY EQUIPMENT MFG. CO.
Hammond, Ind., J. S. Swann

STANOLIND OIL & GAS CO.
Tulsa, Okla., Joseph B. Clark

STAUFFER CHEMICAL CO.
Chauncey, N. Y., J. B. Ceccon

STEARNS, D. E.
Shreveport, La., D. E. Stearns

ST. LOUIS-SAN FRANCISCO RAILWAY CO.
Springfield, Mo., E. L. Anderson

STONE AND WEBSTER ENGINEERING CORP.
Boston, Mass., Edwin B. Powell

SUN PHYSICAL LABORATORY
Newtown Square, Pa., J. M. Pearson

SUNRAY OIL CORP.
Tulsa, Okla., William L. Horner

SYMINGTON-GOULD CORP., THE
Depew, N. Y., J. G. Buehlmann

TAYLOR, ROBERT, & SONS
Salt Lake City, Utah, R. Derrill Taylor

TENNESSEE GAS TRANSMISSION CO.
Houston, Tex., W. C. McGee

TEXAS EASTERN TRANSMISSION CORP.
Shreveport, La., Pat H. Miller

TEXAS ELECTRIC SERVICE CO.
Fort Worth, Tex., P. M. Cordell

TEXAS-EMPIRE PIPE LINE CO., THE
Tulsa, Okla., F. A. Stivers

TEXAS GAS TRANSMISSION CORP.
Owensboro, Ky., Fred D. Stull

TEXAS GULF SULPHUR CO.
Newgulf, Tex., H. E. Treichler

TEXAS-NEW MEXICO PIPE LINE CO.
Midland, Tex., Ralph Troseth

TEXAS PIPE LINE CO., THE
Houston, Tex., Lewis F. Scherer

TIDE WATER ASSOCIATED OIL CO.
Houston, Tex., William H. Vaughan

TRANS-ARABIAN PIPE LINE CO.
New York, N. Y., P. P. Nibley

TRANSCONTINENTAL GAS PIPE LINE CORP.
Houston, Tex., O. W. Wade

TRET-O-LITE CO.
Webster Groves, Mo., Charles M. Blair

TROJAN CONSTRUCTION CO., INC., THE
Oklahoma City, Okla., Felix M. Johnson

TUSCARORA OIL CO., LTD.
Harrisburg, Pa., John W. De Groot

UNION CARBIDE & CARBON CORP.
New York, N. Y., George A. Sands

UNION ELECTRIC COMPANY OF MISSOURI
St. Louis, Mo., George P. Gamble

UNION OIL COMPANY OF CALIFORNIA
Brea, Calif., Vance N. Jenkins

UNION PACIFIC RAILROAD CO.
Los Angeles, Calif., Wiliam Reinhardt

UNION PRODUCING CO.
Shreveport, La., H. R. Bennett

UNITED CHROMIUM, INC.
New York, N. Y., T. G. Coyle

UNITED FRUIT CO.
Boston, Mass., Hartley Rowe

UNITED GAS CORP.
Houston, Tex., J. C. Flanagan

UNITED GAS PIPE LINE CO.
Shreveport, La., M. A. Abernathy

UNITED IRON WORKS
Oakland, Calif., Val Lobanoff

UNITED STATES PIPE & FOUNDRY CO.
Burlington, N. J., A. E. Schuh

UNITED STATES STEEL CO.
Vandergrift, Pa., C. P. Larrabee

UNIVERSAL OIL PRODUCTS CO.
Chicago, Ill., Eugene M. Matson

UTAH OIL REFINING CO.
Salt Lake City, Utah, John W. Cox

WARREN PETROLEUM CORP.
Tulsa, Okla., J. A. La Fortune

WIERTON STEEL CO.
Wierton, W. Va., T. E. Millsop

WHEELING STEEL CORPORATION
Wheeling, W. Va., Henry A. Stobbs

WESTINGHOUSE ELECTRIC CORP.
East Pittsburgh, Pa., Victor J. Kropf

WESTON ELECTRICAL INSTRUMENT CORP.
Newark, N. J., Miles C. Kunz

WILLIAMS BROTHERS CO.
Tulsa, Okla., David R. Williams, Jr.

WILLIAMSON, T. D., INC.
Tulsa, Okla., T. D. Williamson, Jr.

WORTHINGTON PUMP & MACHINERY CORP.
Harrison, N. J., R. J. Allen

WYATT METAL & BOILER WORKS
Houston, Tex., C. A. Haas

YOUNGSTOWN SHEET & TUBE CO., THE
Youngstown, Ohio, Karl L. Fetters

AMONG INDUSTRIES REPRESENTED BY NACE MEMBERS ARE THE FOLLOWING:

Air conditioning
Aircraft
Atomic Research
Automobile

Beverage
Boiler & Tubing
Building Supplies

Cement
Ceramics
Chemical
Construction
Consulting Engineers
Contractors
Corrosion Preventive Services

Distributor

Electric Utilities
Electrical Equipment
Elevator Manufacturers
Engineering Constructor
Engineering Services

Fireproofing Manufacturer
Food
Foundry

Gas
Glass
Governmental Agencies

Heat Treating
Heater Manufacturer

Instrument
Iron
Inter-Industry

Machinery & Tools
Mining & Smelting

Non Ferrous Metals

Oilwell Supply

Paint
Petroleum
Pipe Coatings
Pipe Line Contractors
Plastics
Plating
Pulp and Paper
Pulp and Paper Machinery

Radio
Railroad
Railroad Equipment
Rocket Research
Rubber

Salt
Steel

Telegraph
Telephone
Textile

Universities & Colleges
U. S. Military Services

Valves and Fittings

Water Works & Sewage

Articles of Organization and By-Laws

NATIONAL ASSOCIATION of CORROSION ENGINEERS

Organized October 11, 1943 • Incorporated October 8, 1945 Under the Laws of the State of Texas

Articles of Organization

Effective January 1, 1950. Amended by Letter Ballot of June 5, 1950

ARTICLE I

(Articles of Organization)

Name

The Name of this Association shall be:
National Association of Corrosion Engineers

ARTICLE II

(Articles of Organization)

Objects

This organization shall be a non-profit technological association, and its objects shall be:

(a) To promote the prevention of corrosion, thereby curtailing economic waste and conserving natural resources.

(b) To provide forums and media through which experiences with corrosion and its prevention may be reported, discussed and published for the common good.

(c) To encourage special study and research to determine the fundamental causes of corrosion, and to develop new or improved techniques for its prevention.

(d) To correlate study and research on corrosion problems among technical associations to reduce duplication and increase efficiency.

(e) To promote standardization of terminology, techniques, equipment and design in corrosion control.

(f) To contribute to industrial and public safety by promoting the prevention of corrosion as a cause of accidents.

(g) To foster cooperation between individual operators of metallic plant and structures in the joint solution of common corrosion problems.

(h) To invite a wide diversity of membership, thereby insuring reciprocal benefits between industries and governmental groups as well as between individuals and corporations.

ARTICLE III

(Articles of Organization)

Membership

Section 1. Membership in this Association shall be of three (3) classes: Active, Junior, and Corporate.

Admission to Active, Junior, or Corporate membership shall only be upon approval of application duly made, and in accordance with a procedure which shall be established by the Board of Directors of the Association and embodied in the By-Laws; provided, however, that each application for admission to the grade either of Active Member or of Junior Member shall contain a concise statement of the applicant's qualifications and shall include as references the names of at least two Active Members of the Association in good standing.

Section 2. An Active Member of this Association shall be an individual who is actively engaged in research concerning corrosion, or who is actively engaged in the development, design, and installation of equipment or methods used for the control of corrosion, or the operation and maintenance of structures subject to corrosion.

Section 3. A Junior Member shall be a student or any otherwise qualified person engaged or interested in the advancement of knowledge relating to corrosion control. At the time of his admission he shall be not less than eighteen years of age. His connection with the Association shall cease when he becomes twenty-five years of age, unless he is regularly enrolled as a student in a university or has previously transferred to the grade of Active Member. Junior Members shall receive official publications distributed to members and have all privileges of Active Membership except holding office and voting.

Section 4. A Corporate Member shall be a company, corporation, or other organization, engaged in the production, or sale, or both, of equipment or material for the control or mitigation of corrosion, as approved by the Executive Committee of the Association; or a company, corporation, utility, scientific association or society, board, commission, department (State, County, Municipal, Federal) or other body or organization engaged or interested in corrosion and corrosion control, as approved by the Executive Committee of the Association. Each Corporate Member shall be entitled to designate one representative whose name shall appear on the roll of members opposite the name of the company or organization represented, and who shall have all the rights and privileges of an Active Member, except as expressly provided otherwise in these Articles. No person shall be ineligible to Active Membership by reason of his being or becoming the representative of a Corporate Member. Each Corporate Member, at its pleasure and upon due notice to the Secretary of the Association, may change its representative. When such a change is made, the successor representative shall not succeed to any office, directorship, trusteeship, or committee membership held by the predecessor representative, in the National Association or in any Regional Division or Section, except by action taken in accordance with the Articles of Organization, the By-Laws, or other regulations which provide for regular election or appointment to such positions.

Section 5. All members, other than Junior Members, shall have equal voting power in elections, in determining the adoption or rejection of amendments to these Articles, and in other procedures conducted by vote of members.

Section 6. A member in good standing, of any class, may retire from membership by giving written notice to the Secretary of the Association.

Section 7. For cause, duly set forth in a writing signed by ten Active Members and forwarded to the Secretary of the Association, a member of any class may be expelled from membership in the Association by an affirmative vote by letter ballot of not fewer than three-quarters of the voting members of the Board of Directors; provided, however, that if such action is taken by the Board of Directors, it shall have been completed at a date not more than six months following the receipt by the Secretary of the writing setting forth cause. The Board shall notify the said member in writing of its pending action, at a date sufficiently in advance thereof to permit the member adequate time for preparing statements opposing the expulsion, and shall forward with this notification a copy of the writing setting forth cause. The Board shall afford the member an opportunity for a hearing before it, in person or by its representative, before voting upon the expulsion.

ARTICLE IV

(Articles of Organization)

Officers and Board of Directors

Section 1. The officers of the Association shall be a President, a Vice-President, a Treasurer, and a Secretary. The Secretary shall be appointed by the Board.

Section 2. The Governing Body of the Association shall be

a Board of Directors, hereinafter sometimes called the Board.

Section 3. The Board of Directors shall consist of voting members and members ex-officiis without vote. The voting members shall consist of the President, the Vice-President, the most recent living Past-President, and the Treasurer of the Association, and of Elected Directors. Every member of the Board, including the officers, shall be either an Active Member, or the representative of a Corporate Member, of the Association. Except as otherwise provided in this section, any member of the Board may be both an Active Member and the representative of a Corporate Member.

Elected Directors.—The elected directors shall consist of the following:

One director to represent each Regional Division, to be elected by the members of the Regional Division represented.

Four directors to be elected by the members of the Association from the Active Membership of the Association. Representatives of Corporate Members shall not be eligible for election as directors in this group.

Five directors to be elected by the members of the Association from the representatives of Corporate Members of the Association.

Directors Without Voting Power. Directors ex-officiis and without voting power shall consist of the following:

The Chairman of the Policy and Planning Committee.
The Chairman of the Publication Committee.
The Chairman of the Technical Practices Committee.
The Chairman of the Regional Management Committee.

Section 4. The terms of the Directors and Officers shall start at the beginning of the last day of the annual convention held subsequent to the date of their election. If, for any reason, a Director is not elected until after the date of the holding of the annual convention at which he should have commenced his term of office, his term of office shall begin at the date that the advice of his election is received by the Secretary. The terms of Directors and Officers shall terminate at the beginning of the last day of the annual convention in the year of expiration of their terms of office.
If for any reason the first day of the annual convention of the Association does not occur between January 1 and June 30, inclusive, in any year, then the terms of newly elected Directors and Officers shall commence on July 1, of such year; and the terms of office of the Directors and Officers who are to be succeeded shall terminate on that date.

Section 5. No person who is or has been an elected director, as defined in Section 3 of this Article, shall be eligible to a succeeding term as an elected director until three years shall have elapsed following the completion of his earlier term of service as an elected director.
No person who is or has been President shall be eligible to a succeeding term as President or to a term as Vice-President until four years shall have elapsed following the completion of his earlier term as President. Except as provided in Section 3 of this Article, no person who is or has been President shall be eligible to membership, with voting power, upon the Board of Directors, until four years shall have elapsed following the completion of his term as President.
Except by election as President, and as a Past-President in accordance with Section 3 of this Article, no person who is or has been Vice-President shall be eligible to membership, with voting power, upon the Board of Directors, until three years shall have elapsed following the completion of his term as Vice-President.
In observing the limitations placed in the two paragraphs next preceding with respect to the intervals of time between occupancies by a single individual of the same or different offices and of membership upon the Board of Directors, each year of the interval shall be understood to mean the then current term of office of an elected officer of the Association, as provided in Article VIII, Section 6 of these Articles of Organization.

Section 6. The Officers of the Association shall be the Officers of the Board.

Section 7. The Board of Directors shall be the legal representative of the Association. It shall have power to expend the funds of the Association, or to invest the same, but shall not incur indebtedness beyond the assets of Association. It shall establish policies for the Association and its officers and for the several committees of the Board and of the Association.
The Board shall prepare regulations, and shall embody them in the By-Laws, regarding the payment, and, in special cases, the remission, of annual dues for all classes of members, including the amounts to be paid, the dates and methods of payment, the conditions under which members may be suspended or otherwise penalized for non-payment of dues, and the conditions under which members so suspended may be reinstated. The Board shall have power to make such changes from time to time in the regulations so established as it shall determine to be advisable in the best interests of the Association and its members.
The Board shall prepare and enforce, and shall have power to amend, By-Laws of the Association, not in conflict with these Articles of Organization, for the conduct of the business of the Association. It shall exercise other powers delegated to it in these Articles of Organization and shall have authority, in the administration of the affairs of the Association, to perform such acts, not in conflict with these Articles of Organization and amendments thereto, as in its judgment will promote the well-being of the Association and the members thereof.

Section 8. The Board may exercise the above described functions either in session at stated or duly called meetings or by letter ballot. Any matter that requires action by the Board of Directors at a time not conveniently related to a regular or called meeting may be submitted to it for approval by letter ballot.
The Board may, by resolution, designate the classes or types of Association business which may be submitted to it for approval by letter ballot. Matters not thus designated may be considered by the Executive Committee in the exercise of its stated duties (Article VI, Section 1) or the Executive Committee may refer such matters to the Board for approval by letter ballot. Such action by the Executive Committee may be taken either at a meeting of the Committee or by a letter ballot of the Committee if the initiation of said letter ballot is directed by the President in a letter addressed to the Secretary.
Except as otherwise provided by resolution of the Board, or in these Articles of Organization, matters submitted to it by letter ballot shall obtain an affirmative recorded vote of two-thirds of the Board membership to secure approval. The results of all letter ballots shall be reported to the Board at its next meeting.

Section 9. A quorum of the Board shall consist of a majority of its voting members.

Section 10. Regular meetings of the Board shall be held during the annual convention of the Association, on such days as may be decided by the Board. Other meetings may be held at the direction of the President, or at the request, in writing, of five members of the Board, and on such notice as shall be provided in the By-Laws.

Section 11. No Board Member may be represented in any action required of him as a Board Member by any other person; nor may he vote, by letter, upon any matter scheduled for consideration at a duly called meeting of the Board.

Section 12. The President shall have general supervision of the affairs of the Association and shall preside at all conventions of the Association and meetings of the Board and of the Executive Committee. In his absence, the Vice-President shall serve, or in the absence of the Vice-President, the President shall designate a Presiding Officer to act in his stead at such conventions or meetings. He shall perform such other duties as are assigned to him in these Articles of Organization and in the By-Laws of the Association.

Section 13. The Vice-President shall assist the President in the performance of the latter's duties. In the event of the absence of the President, or his inability to serve, the Vice-President shall act in his stead. The Vice-President shall perform such other duties as are assigned to him in these Articles of Oragnization and in the By-Laws of the Association.

Section 14. The Treasurer shall have charge of the funds of the Association, and shall disburse the funds of the Association as authorized by the Board of Directors. He shall be bonded at the expense of the Association, and to an amount to be determined by the Board. He shall perform such other duties as are assigned to him in these Articles of Organization and in the By-Laws of the Association, or by direction of the Board.

Section 15. The Secretary shall be a member of the Association or may be employed as Executive Secretary of the Board.

He shall supervise the work of all employees, and shall have charge of the records of the Association. He shall attend all conventions and meetings of the Association and of the Board, and shall prepare the business and duly record the proceedings thereof.

He shall see that all moneys due the Association are collected, and shall promptly deposit the same to the credit of the Association, and shall certify to and pay bills against the Association as authorized by the Board of Directors. He shall be bonded at the expense of the Association, and to an amount to be determined by the Board. He shall have charge of the books of account of the Association, which shall be audited annually by certified public accountants, to be appointed by the Board.

The Secretary shall perform other duties assigned to him in these Articles of Organization and in the By-Laws of the Association, and as directed by the Board.

ARTICLE V

(Articles of Organization)

Meetings of the Association

Section 1. Except as otherwise determined by the Board of Directors as provided in Section 3 of this Article, there shall be an annual convention of the Association, the first day of which shall be between the dates, inclusive, of January 1 and June 30. The Board of Directors shall fix the time of the annual convention between these dates, and its place.

Section 2. Meetings of the Association in addition to the annual convention may be held upon determination by the Board of Directors, who shall have power to declare the purpose of any such meeting, and to fix its time and place.

Section 3. Notwithstanding Section 1 of this Article, the Board of Directors, by an affirmative vote of not less than two-thirds of its voting members, may determine the existence of extraordinary conditions requiring the postponement or abandonment of the annual convention in any single year. If the Board shall so determine a postponement, it shall, by majority vote, fix the time and place of the annual convention without limitation as to date, except that the first day of the convention shall be within the calendar year in question.

ARTICLE VI

(Articles of Organization)

Committees of the Association

Section 1. The Board of Directors shall annually appoint an Executive Committee of not fewer than five directors, one of whom shall be the President of the Association, who shall act as Chairman of the Committee. No director appointed to the Executive Committee shall have voting power in that Committee unless he possesses voting power in the Board of Directors, nor shall any member of the Executive Committee without voting power in the Board be counted in determining the existence of a quorum at meetings of the Executive Committee. The Board, by resolution or in the By-Laws, shall fix requirements for a quorum of the Executive Committee.

The duties of the Executive Committee shall be to direct the administrative work of the Association and to carry out the policies of the Board between meetings of the latter.

Section 2. The following Standing Committees or members thereof shall be appointed annually as provided in paragraphs below of this section:

Technical Practices Committee
Publication Committee
Regional Management Committee
Policy and Planning Committee
Inter-Society Corrosion Committee

Technical Practices Committee. This committee shall consist of at least ten members. Any resolution, report or publication which undertakes to establish, in the name of the Association or any of its sections or divisions, professional or technical standards, shall be approved by this committee before further action.

All appointive members of this committee shall be appointed by the Chairman of the Committee. The Chairman shall be appointed by the President. The President and Vice-President shall be members ex-officiis.

Publication Committee. This committee shall consist of at least five members. It shall have control of all publications of the Association.

All appointive members and the chairman of this committee shall be appointed by the President. The President and Vice-President shall be members ex-officiis.

Regional Management Committee. The membership of this committee, other than the chairman, shall include all the Regional Directors and may include other members of the Association at the discretion of the President. The chairman shall not be a Regional Director nor an officer of the Association or of any of its regions or sections. This committee shall be responsible for the organization and general regulation of Regional Divisions and for their relations with the Association.

All appointive members and the chairman of this committee shall be appointed by the President. The President and Vice-President shall be members ex-officiis.

Policy and Planning Committee. This committee shall consist of six members in addition to the chairman. Appointments shall be made so that one-third of the six members shall be replaced each year, each member serving a three-year period except for the appointments made upon the first formation of the committee. Any member or previous member of the committee shall be eligible for reappointment after the lapse of a three-year period following the conclusion of an earlier term of membership. The Secretary of the Association shall be a member of the Committee ex-officio.

This committee shall advise the Board upon matters of policy or planning referred to it by the Board. Without limitation upon the power of the Board to act as in its judgment may be required by circumstances, the committee shall make recommendations to the Board upon all matters of long-term policy and matters involving changes in the functions of the Association.

All appointive members and the chairman of this committee shall be appointed by the President. The President and the Vice-President shall be members ex-officiis.

Inter-Society Corrosion Committee. The Inter-Society Corrosion Committee is hereby recognized as a Standing Committee of the National Association of Corrosion Engineers, subject to such rules as the Inter-Society Corrosion Committee shall adopt for the guidance and control of its affairs. The Board of Directors shall have power, by adoption of by-laws or otherwise, to make such provision as in its judgment will best serve to advance the interest of the Association, in conformance with the declared purposes and rules of procedure of the Inter-Society Corrosion Committee.

Representatives upon the Inter-Society Corrosion Committee from this Association shall be appointed by the President.

Section 3. The Board shall have power to appoint such committees, in addition to the Standing Committees, as it shall find necessary or desirable in preserving and advancing the interests of the Association. The Board, after determining the need or desirability of any such committee, may delegate, to the Executive Committee or to the President, authority to appoint members and chairmen of such committee. The duration of membership on any such committee shall be as determined by the Board.

Where the number of members of a Standing Committee is prescribed in these Articles of Organization, either definitely or by specifying a minimum number, ex-officio members shall not be included in meeting the numerical requirements in appointments to membership.

Section 4. Chairmen of committees shall have power to appoint such subcommittees as they find necessary or desirable, and in making such appointments, they shall not be limited, in the selection of members, to the roster of membership of the committee.

ARTICLE VII

(Articles of Organization)

Regional Divisions

Section 1. In order to promote more effectively the objectives of the Association, Regional Divisions of the Association shall be formed. The members of each Regional Division shall be the members of the Association in good standing, of all classes, living or having their principal places of business in a corresponding geographical region of the area of continental North America, which area shall include that of the continental United States, and may include the area of Canada and the area of Mexico, as provided in Section 2 of this Article. There shall be not fewer than five and not more than ten Regional Divisions.

Section 2. The Board of Directors shall divide the area of the continental United States or an alternative area of continental North America as provided in Section 1 of this Article, into a number of regions equal to the number of Regional Divisions, and shall have power to make changes in the number of Regional Divisions and in the boundaries of the regions, within the limits prescribed in Section 1 of this Article, and as provided below in this Section.

Upon petition duly signed by fifty members residing or having their principal places of business within an area specified in the petition, the Board may establish an additional Regional Division for the specified area or for an area generally conforming to it, provided, however, that the total number of Regional Divisions shall not exceed ten.

When, in its judgment, the interests of the Association will best be served thereby, the Board may reduce an existing number of Regional Divisions and the corresponding number of regions.

Without alteration in the number of Regional Divisions, the Board may change the boundaries of existing regions, when, in its judgment, the interests of the Association will best be served thereby.

The Board shall cause descriptions of the boundaries of regions to be published, by map or otherwise, and shall revise and reissue such descriptions when changes are made.

Section 3. For purposes of orderly administration of its affairs, each regional division shall establish rules and by-laws for itself not in conflict with these Articles of Organization or with the By-Laws of the Association; provided, however, that such rules and by-laws shall be approved by the Board of Directors of the Association. Each regional division shall choose a governing body and administrative and executive officers for itself, in accordance with procedures provided in its rules and by-laws.

Section 4. Each regional division shall be represented upon the Board of Directors by one regional director who shall be elected as provided in Article VIII, Section 7, of these Articles.

Section 5. The Board of Directors of the Association shall establish, in the By-Laws of the Association, general rules and regulations, not in conflict with these Articles of Organization, for the organization of regional divisions, for the conduct of their affairs, and for their relations with the National Association.

ARTICLE VIII

(Articles of Organization)

Nomination and Election of Officers and Directors

Section 1. A Nominating Committee shall be formed each year consisting of the President, the Vice-President, and the most recent living Past-President of the Association, and of members to represent the Regional Divisions of the Association. If for any reason it is not possible for the President, or the Vice-President, or the most recent living Past-President, to serve upon the Committee, then the Treasurer of the Association shall serve in the position otherwise vacant; and if the Treasurer shall be unable to serve, the Executive Committee shall appoint an Active Member. The President, or in the event of his absence or inability to serve, then the Treasurer, shall be Chairman of the Nominating Committee. If the Treasurer shall also be unable to serve, the Chairman shall be appointed by the Executive Committee.

Section 2. The Governing Body of each Regional Division shall appoint the representative, upon the Nominating Committee, of that Regional Division. No Regional Director shall be so appointed.

The principal executive officer of each Regional Division shall report, to the Secretary of the Association, the name of the member of the Nominating Committee selected to represent his Regional Division. In the event of the failure of any Regional Division to make such report on or before the date fixed for the information of the Nominating Committee under the provisions of Section 5 of this Article, the Executive Committee of the Association shall designate a member of the said Regional Division to serve upon the Nominating Committee.

Section 3. Through its Chairman, the Nominating Committee shall report, to the Secretary of the Association, one nominee or not more than two nominees for each of the National offices of President, Vice-President, and Treasurer, and one nominee or not more than two nominees for each Elected Director position (except directors representing Regional Divisions) which requires to be filled in the next following administrative year under the provisions of Section 8 of this Article; provided, however, that no person shall be nominated for any of the three offices above-named unless he is an Active Member, or the representative of a Corporate Member, of the Association in good standing, and has served or is serving upon the Board of Directors, nor unless he has signified his willingness to serve in the office in question.

The Secretary shall prepare a ballot containing the name or names of the nominees of the Nominating Committee for each office and each directorship to be filled by election, except Regional Division directorships.

Not later than a date to be fixed as provided in Section 5, of this Article, the Secretary shall inform all members of the Association, by publication or otherwise, of the list of nominees reported to him by the Nominating Committee; and at any time prior to a later date, to be fixed as provided in Section 5 of this Article, additional nominations may be made by petition forwarded to the Secretary and signed by at least twenty-five Active Members. Any such nominees for the office of President, Vice-President, or Treasurer shall qualify as provided in the first paragraph of this section. Upon receipt of such petition, the Secretary shall, after acceptance of each such nomination by the nominee, add such names to the ballot prepared by him. The complete list of nominees, where there are more than one, for each office or directorship, shall be arranged in alphabetical order on the ballot.

Section 4. At a date to be fixed as provided in Section 5 of this Article, but not later than February 15, the Secretary shall forward by mail, to every member of the Association entitled to vote (to their representatives, in the case of Corporate Members), a copy of the complete ballot prepared as provided in Section 3 of this Article. The ballot

shall, in addition, contain a notice that the voter may, if he wishes, vote for persons other than the nominees, and spaces shall be provided for recording such votes. The ballot shall state the residence, as well as the name, of each nominee, and shall prescribe a required date of return, which shall not be later than March 15.

The Board of Directors shall prescribe and enforce rules for the conduct of the election to safeguard the secrecy of all ballots and to prevent the casting of ballots by persons not authorized to vote. Every returned ballot received by the Secretary after the prescribed date of return shall be void. Any ballot so marked as to indicate a vote for more than one nominee for any one office or directorship shall be void in its entirety.

The Secretary together with two or more tellers appointed by the President shall meet at a time and place directed by the President and shall open and count all ballots cast by persons entitled to vote.

The report of the Tellers for the election of the incoming President, Vice-President, and Treasurer and Directors shall be declared by the President at the annual convention on certificates of the Tellers. The candidates who shall have received the highest number of votes cast for the several offices shall be declared elected. If there be a tie vote the President shall order a ballot to be taken to decide which of the candidates who have received the same number of ballots shall be chosen.

Section 5. Not later than August 1 of each year, the Executive Committee of the Association shall establish a schedule of dates for the completion of each of the several steps involved in the formation and functioning of the Nominating Committee, and in the preparation, forwarding, and return of election ballots. This schedule shall provide a period of at least six weeks, following the appointment of the Nominating Committee, for the deliberations of the Committee and the filing of its report with the Secretary and shall provide a period of not less than thirty days nor more than thirty-five days for the preparation and filing of nominations by petition. This schedule shall provide adequate intervals of time for the proper performance of their functions by all individuals and groups of individuals who shall be concerned in conducting the nomination and election of officers and directors and in the declaration of the results of the same. This schedule shall conform to the two dates stated in Section 4 of this Article with regard, respectively, to the forwarding of letter ballots to voters by the Secretary and to the return of letter ballots to the Secretary.

The Executive Committee, through the Secretary, shall provide needed information regarding the schedule to all persons concerned with the conduct of the nominations and of the election.

Section 6. The terms of the Officers so elected shall commence at the beginning of the last day of the annual convention, following the date of their election; and shall cease at the beginning of the last day of the next annual convention. But, if an annual convention is not held beginning prior to July 1, that date shall be the date of the beginning of the term of office of an officer. Said term shall be for approximately one year, but shall continue until a successor has been chosen.

In case of a vacancy in the office of President, the Vice-President shall act in his place for the unexpired term. In case the Vice-President cannot act, the latest living Past President shall do so.

In the case of a vacancy in the office of Treasurer, the Executive Committee shall appoint an Active Member to fill the office for the unexpired term.

Section 7. One Director to represent each Regional Division shall be nominated and elected by the members of the Division in the same manner as the Presiding Officer of that Division is elected. The manner of such election shall receive the approval of the Board. The Director so elected shall be an Active Member and shall reside in the territory of the Division at the time of his election. Should he cease to reside in the territory of the Division before his term of office is ended, it shall be within the power of the Division to replace him.

The term of each Director so elected shall be for approximately three years, beginning with the last day of the annual convention immediately following his election, or on the following July 1. When a new Regional Division is established, the initial term of the Director representing such Region shall be as determined by the Board.

In the case of the retiring, for any cause, of a Director representing a Division, before his term is completed, the governing body of the Division shall designate his successor who shall serve for the unexpired portion of the term.

Section 8. (a) Directors from the roster of Active Members shall be nominated and elected to the number required to establish or maintain the number of directors of this group provided for in Article IV, Section 3, of these Articles.

(b) Directors from the roster of representatives of Corporate Members shall be nominated and elected to the number required to establish or maintain the number of directors of this group provided for in Article IV, Section 3, of these Articles.

The term of office of each director in group (a) or group (b), above, shall be three years; provided, however, that initial nominations and elections of directors in these groups, conducted in accordance with this section and the preceding sections of Article VIII, shall be for such terms, not longer than three years, as will provide as early as practicable for terms of three years' duration, with not more than two directors in either group retiring at the end of any administrative year; and provided further that any director, previously chosen or appointed *ad interim*, under provisions antecedent to this Article VIII, to represent any class of membership, shall continue in office until the unexpired portion, if any, of the term for which he was elected or appointed shall have been served.

Section 9. Notwithstanding the coming into effect of this Article VIII at any date, an election of officers, and of directors as provided for in Section 3 of Article IV, shall be conducted in accordance with the methods of election specified in the Articles of Organization in effect immediately prior to such date, if the Board of Directors shall determine that such election is necessary in order to fill positions which otherwise would be vacant; provided, however, that the terms of office of any directors so elected shall be for such periods, not exceeding two years, as will, in the discretion of the Board, establish membership on the Board of Directorships in accordance with Article IV, Section 3 and the provisions of Section 8 of this Article VIII.

Section 10. If a director chosen from the roster of Corporate Member representatives, or from the roster of Active Members excluding Corporate Member representatives, shall retire for any reason before his term is completed, the Board shall designate his successor, who shall serve for the unexpired portion of the term.

ARTICLE IX

(Articles of Organization)

Amendments

Proposals to amend these Articles of Organization, signed by at least ten Members of the Association, may be submitted in writing to the Board not later than the fifteenth day of November in any year.

The Board shall consider the proposals, and the proposers shall be notified of the Board's opinion in regard thereto not later than the twentieth day of January next following.

The proposers may then withdraw their proposal, accept any change suggested, or insist on the original form, sending their decision to the Secretary not later than the eleventh day of February next following.

The proposals, as accepted by the proposers, shall be mailed to the Members not less than fourteen days before the next following annual convention, or if such mailing is impossible, no less than fourteen days before the annual convention of the next following year.

Proposals to amend these Articles of Organization may also be made by the Board and shall be mailed to the Members not less than twenty-one days before an annual convention.

All proposals shall be submitted for discussion at the annual

convention next following their circulation, as provided above, to the Members.

The members there present may amend the proposals by a two-thirds vote of those voting at the convention and all amendment proposals which have been duly proposed, circulated, submitted, considered, and approved by a majority vote of those voting at the convention shall be submitted to the voting membership by letter ballot.

The Secretary shall issue the letter ballot not later than two months after the annual convention at which the proposals were submitted for discussion, and duly authorized, as provided in the preceding paragraph, for submission to the voting membership.

On written request of three or more members the letter ballot shall be accompanied by a statement giving reasons for and against the proposal, edited by a Committee appointed by the Board, consisting of an equal number of members favoring and members opposing the proposal.

The letter ballot shall be returnable to the Secretary not later than three months after the annual convention at which the proposals were submitted for discussion.

Three tellers appointed by the Board shall forthwith count the ballots and report the result to the Board.

An affirmative two-thirds of all valid ballots shall be necessary for the amendment or repeal of any part of these Articles of Organization.

The amendments as passed shall take effect at the beginning of the next calendar year, except that changes affecting the tenure of office of an Officer of the Association shall not take effect until the next annual convention.

By-Laws

Effective March 11, 1951

ARTICLE I

(By-Laws)

Membership

Section 1. Application for Active, Junior, or Corporate Membership shall be made on the forms provided by the Association. Each application for admission as an Active or Junior Member shall contain a concise statement of the applicant's qualifications and shall include as references the names of at least two Active Members of the Association in good standing.

Section 2. All applications shall be forwarded to the Secretary, who shall submit them to the Executive Committee. An affirmative vote of a majority of the Executive Committee shall be required for election to membership which shall become effective upon the payment of dues.

Section 3. No members with dues in arrears for three months shall receive the publications of the Association until such arrears are paid, and members in arrears for one year shall be automatically dropped by the Secretary from the list of members.

Section 4. The Board may, for sufficient cause, temporarily or permanently excuse from the payment of annual dues, any member who from ill health, advanced age, or other good reason, is unable to pay such dues, and the Board may waive the whole or part of dues in arrears, or accept in lieu thereof desirable additions to the library or collections.

Section 5. A member dropped for nonpayment of dues may be reinstated by the Executive Committee on payment of the dues in arrears at the time he was dropped, plus the dues payable for the year of reinstatement. He shall thereupon be entitled to receive such withheld back numbers of the Association's publications issued during the period of the paid-up arrears as are then available, as well as available publications issued during the year of reinstatement.

Section 6. A member in good standing, of any class, may retire from membership by giving written notice to the Secretary of the Association.

ARTICLE II

(By-Laws)

Dues

Section 1. Each ACTIVE MEMBER shall pay annual dues of seven dollars and fifty cents ($7.50) except that a new ACTIVE MEMBER elected subsequent to June 30 shall pay dues of five dollars ($5.00) for the remainder of that fiscal year.

Section 2. Each JUNIOR MEMBER shall pay annual dues of two dollars and fifty cents ($2.50).

Section 3. Each CORPORATE MEMBER shall pay annual dues of one hundred dollars ($100.00) and may, at its option, make payment annually on the anniversary date of its initial payment.

Section 4. The fiscal year of the Association shall begin on January 1 and terminate on December 31. Annual dues shall be payable in advance on the first day of the dues-paying year and it shall be the duty of the Secretary to notify each member on or before such date of the amount due for the ensuing dues-paying year.

Section 5. A newly elected member shall be entitled to all of the publications of the Association that are distributed during the year or portion thereof for which dues have been paid.

ARTICLE III

(By-Laws)

Meetings

Section 1. Notice of meetings of the Board of Directors shall be issued by the Secretary to all members of the Board at least 15 days in advance of such meetings.

Section 2. Meetings of the Regional Divisions shall be held as determined by the rules and by-laws of Regional Divisions.

Section 3. Registration fees to be paid by members or others attending meetings or conventions of the Association shall be as determined by the Board.

Section 4. All conventions and meetings of the Association shall be conducted according to "Robert's Rules of Order."

ARTICLE IV

(By-Laws)

Officers and Board of Directors

Section 1. In addition to those duties prescribed in the Articles of Organization and such other duties as may be directed by the Board, the Treasurer shall make such reports to the Board as he may find necessary or as may be called for by the Board.

He may, with approval of the Board, establish a drawing account for the Secretary.

Section 2. In addition to those duties prescribed in the Articles of Organization and such other duties as may be directed by the Board, the Secretary shall be ex-officio a member and Secretary of the Executive Committee, the Inter-Society Corrosion Committee, the Policy and Planning Committee, the Publication Committee, the Regional Management Committee, and the Technical Practices Committee.

He shall forward each month to each member of the Board, and to the Chairman of each Regional Division, financial summaries of receipts and disbursements.

He shall make annual and such other reports to the Board as he may find necessary or as may be called for by the Board.

Section 3. All bills payable by the Association and checks in payment thereof shall be countersigned by the Secretary and the Treasurer, except that the Board may by resolution authorize the Secretary to make certain payments from his drawing account not to exceed definite amounts as may be periodically determined by the Board. The Secretary and Treasurer may submit, for approval of the Board, additional regulations governing disbursement of the funds of the Association, upon their own application or as directed by the Board.

Section 4. The Secretary's appointment shall be deemed continuously effective until reappointment or until a successor shall have been appointed.

Section 5. Within thirty days following the commencement of terms of office of incoming directors and officers, the Secretary and the Executive Committee shall be appointed by the Board at its first convened meeting, and in the absence of a quorum, the Board members there present shall constitute a nominating committee for the purpose of making such appointments, subject to the approval of the Board by letter ballot but, in any event, to remain effective until the next Board meeting.

Section 6. Except as otherwise provided in the Articles of Organization or By-Laws, all questions before the Board shall be decided by a majority vote.

ARTICLE V

(By-Laws)

Committees

Section 1. Unless otherwise provided by resolution of the Board of Directors, a majority of the voting members of the Executive Committee shall constitute a quorum; in determining the existence of a quorum, members of the Executive Committee without voting power shall not be counted.

Section 2. Any vacancy in the Executive Committee shall be filled by the Board of Directors at any regular or special meeting or by letter ballot.

Section 3. The Publication Committee shall prepare rules which shall govern the preparation, presentation, acceptance and publication of all papers and such other matters of similar nature, including advertisements, as the best interests of the Association may require.

ARTICLE VI

(By-Laws)

Letter Ballots

Section 1. In such voting by the national membership as is required by the Articles of Organization to be by letter ballot and to be secret, each ballot shall be placed unsigned in a sealed envelope. The sealed envelope shall then be forwarded to the Secretary in a forwarding envelope which shall be signed by or for, and clearly indicate the name of, the member voting.

Section 2. Before opening the sealed envelopes and counting the ballots, the Secretary and such tellers as may be required by the Articles of Organization, the By-Laws or by resolution of the Board, shall first determine that all ballots to be counted shall have been cast by persons entitled to vote.

Section 3. In all other voting by letter ballot, the Board of Directors shall prescribe such methods as are proper and practicable, such methods to require in any event a determination that all ballots to be counted shall have been cast by persons entitled to vote.

Section 4. In the election of officers and directors of the Association, the ballot prepared by the Secretary shall be accompanied by a brief biographical sketch covering generally the following information with respect to the qualifications and experience of nominees, such information to be prepared by the Association headquarters staff:

(a) residence;
(b) company affiliation, position and title, if available;
(c) previous service as an officer, director or member of a committee of the National Association or any Region or Section thereof;
(d) any other pertinent general information which would serve as a guide to the membership in electing officers and directors of the Association.

ARTICLE VII

(By-Laws)

Regional Divisions

Section 1. Each Regional Division shall adopt, and may subsequently amend, rules and by-laws for the administration of its affairs not in conflict with the Articles of Organization or the By-Laws of the Association, which shall be effective upon notification of the approval of the Board of Directors of the Association and shall conform to the following requirements:

(a) The fiscal year of each Regional Division shall be the calendar year, January 1 to December 31.
(b) Each Regional Division shall be administered by a Regional Board of Trustees consisting of a Chairman, a Vice Chairman, and a Secretary-Treasurer of the Division, a Regional Director, one additional member who may be the most recent past Chairman of the Division, and in addition thereto, if the Regional By-Laws so provide, one representative from each of the Sections of the Regional Division.
(c) A quorum of the Regional Board of Trustees shall consist of not less than three of its members, at least one of which shall be an officer of the Regional Division.
(d) No dues shall be collected from members of Regional Divisions by Regional Division organizations; but this limitation is not to be construed as prohibiting voluntary contributions to Regional Division organizations provided the making of such contributions does not in any way result in penalizing members not contributing.
(e) In all elections of regional officers and other members of Regional Boards of Trustees held at meetings of the Regional membership, at least three weeks' notice of the meeting and election, including the names of nominees, shall be given to all members of record in the Regional Division, and a quorum for such purposes shall be constituted by the members present and qualified to vote at the meeting. Nomination procedure shall in all elections accord to the members, as well as to a nominating committee, the right by written petition or otherwise to make nominations. Elections may be held by letter ballot if specifically authorized by the Regional By-Laws provided at least three weeks' notice of the closing date for nominations is given to all members of record in the Regional Division.
(f) Membership in the Regional Divisions and eligibility for election to the Regional Boards of Trustees shall be limited to members of the Association in good standing. However, non-members of the Association may attend Regional Division meetings, as guests, in the discretion of the Regional Board of Trustees.

Section 2. After each Regional Division is established and its rules and by-laws have become effective, the Board of Directors of the Association may authorize the Secretary and the Treasurer to disburse to such Regional Division such amounts of Association funds and for such purposes as the Board shall determine to be in furtherance of the purposes and policies of the Association.

The Board of Directors of the Association shall prescribe procedures for advances of funds to Regional Divisions and for periodic accountings.

Section 3. Any member of the Association who resides in a locality which is not included in the territory embraced by an existing Regional Division, may upon written request to the Board of Directors of the Association be included in the membership of any Regional Division. The Secretary of the Association shall notify the Secretary of the Regional Division of the enrollment of the member.

Whenever a new Regional Division is formed or an existing Regional Division has its territory extended so as to include the locality where such member resides, he shall automatically be included in the membership of such Regional Division.

Section 4. Any Regional Division may be dissolved by the Board for reasons which it believes are good and sufficient.

ARTICLE VIII

(By-Laws)

Sections

Section 1. Each Regional Division may provide in its rules and by-laws for the establishment of local Sections to serve geographically unified areas within its boundaries.

Section 2. Each local Section shall adopt, and may subsequently amend, rules and regulations for the orderly admin-

istration of its affairs not to conflict with the Articles of Organization or By-Laws of the Association or the Rules and By-Laws of its Regional Division, which rules and regulations shall become effective upon notification of the approval of the Board of Trustees of its Regional Division and shall conform to the following requirements:

(a) The fiscal year of each Section shall be the calendar year, January 1 to December 31.

(b) Each Section shall be administered by at least a Chairman, Vice Chairman and Secretary-Treasurer, who shall constitute the Governing Board.

(c) A quorum of the Governing Board shall consist of not less than two of its members.

(d) No dues shall be collected from members of Sections by Section organizations; but this limitation is not to be construed as prohibiting voluntary contributions to Section organizations provided the making of such contributions does not in any way result in penalizing members not contributing.

(e) In all elections of Section officers held at Section meetings, at least three weeks' notice of the meeting and election, including the names of nominees, shall be given to all members of record in the Section, and a quorum for such purposes shall be constituted by the members present and qualified to vote at the meeting. Nomination procedure shall, in all elections, accord to the members, as well as to a nominating committee, the right by written petition or otherwise to make nominations. Elections may be held by letter ballot if specifically authorized by the Section Rules and Regulations provided at least three weeks' notice of the closing date for nominations is given to all members of record in the Section.

(f) Membership in the Sections and eligibility for election to the Governing Boards of Sections shall be limited to members of the Association in good standing. However, non-members of the Association may attend Section meetings, as guests, in the discretion of the Governing Board.

Section 3. After each section is established and its rules and regulations have become effective, the Board of Directors of the Association may authorize the Secretary and the Treasurer to disburse to such Section such amounts of Association funds and for such purposes as the Board shall determine to be in furtherance of the purposes and policies of the Association.

The Board of Directors of the Association shall prescribe procedures for advances of funds to Sections and for periodic accountings.

Section 4. Any member of the Association who resides in a locality which is not included in the territory embraced by an existing Section may upon written request to the Regional Board of Trustees be included in the membership of any Section. The Secretary-Treasurer of the Regional Division shall notify the Secretary-Treasurer of the Section of the enrollment of the member.

Whenever a new Section is formed or an existing Section has its territory extended so as to include the locality where such member resides, he shall automatically be included in the membership of such Section.

Section 5. Any Section may be dissolved by the Regional Board of Trustees of the Regional Division which established such Section, with the consent of the Board of Directors of the Association, for reasons which are good and sufficient to both Boards.

ARTICLE IX

(By-Laws)

Publications

Section 1. All publications of the Association shall be issued under the direction of the Board and shall be copyrighted as far as is practicable and proper.

ARTICLE X

(By-Laws)

Amendments

Section 1. The Board of Directors may amend these By-Laws in any manner not inconsistent with the Articles of Organization by a two-thirds vote of those voting at any meeting of the Board; or by sealed letter ballot, provided a copy of the amendment proposal has been mailed by the Secretary to each member of the Board at least thirty days prior to such letter ballot.

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